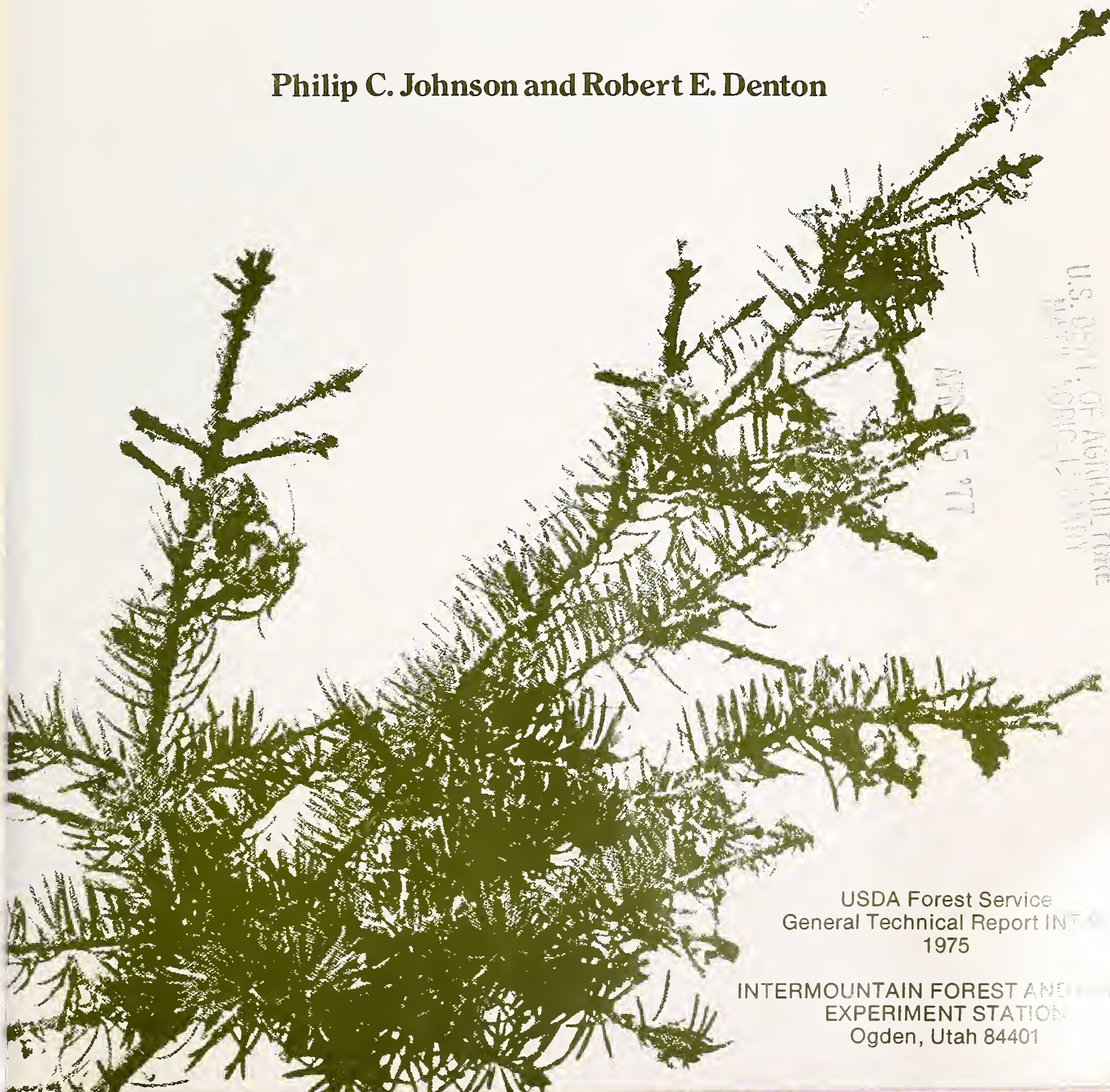
OUTBREAKS OF THE WESTERN SPRUCE BUDWORM IN THE AMERICAN NORTHERN ROCKY MOUNTAIN AREA FROM 1922 THROUGH 1971

Philip C. Johnson and Robert E. Denton



USDA Forest Service
General Technical Report INT-
1975

INTERMOUNTAIN FOREST AND
EXPERIMENT STATION
Ogden, Utah 84401

ABSTRACT

The western spruce budworm has severely damaged more than 15 million acres of publicly and privately owned coniferous forests chiefly in the American northern Rocky Mountain area. Abundant information about behavior of the budworm, characteristics of outbreaks of its populations, and kinds and severity of damage is available from National Forest ranger district annual reports of insect conditions, which were started in 1925, and from later reports of damage surveys made by forest entomologists since 1948. The first report of an outbreak of this insect appeared in January 1922. Numerous outbreaks have appeared since then, chiefly in forests of Montana and Idaho but also in Utah and Wyoming. In a few ranger districts in Montana infestation has continued until now, but in many locations the budworm outbreaks have continued for less than 5 years.

For about 30 years following the first reported outbreak, forest entomologists were primarily concerned to learn about the biology of the budworm and the kinds and severity of damage it caused. Since 1950, they have developed sophisticated methods for surveying outbreaks, mapping their exact areas and assessing damage; also they have experimented with various chemicals in trying to control populations and thereby prevent further outbreaks.

The western spruce budworm has chiefly attacked the Douglas-fir, grand and subalpine firs, and Engelmann spruce; it has also attacked western larch, ponderosa pine, and western hemlock. Nearly all forests within the territories of the Northern and Intermountain Regions of the USDA Forest Service that contain these host species have been attacked sometime within the past 50 years. By partial defoliation of nearly all trees over large areas the budworm eliminates age classes of timber and thereby abruptly changes modes of forest management; it vastly increases fire hazard and eliminates recreational values.

In a typical outbreak, the budworm may consume part or all of the needles produced in the current season. If it consumes all of the needles produced during successive seasons, the tree may die within 3 to 5 years.

Since no natural agent capable of adequately controlling outbreaks of the budworm has appeared, forest entomologists have tried several chemicals as aerial sprays in attempts to control the pest and reduce its damage. These have included DDT, malathion, and several others. Their effectiveness, persistence, and side effects are varied. Despite availability of increasingly sophisticated devices for survey and development of several reasonably effective chemical controls more than 5 million acres of forests are still infested. The task of control is so great that thus far control programs have been concentrated only on areas where heavy damage has occurred or where extensive tree mortality is imminent. This indicates that the budworm problem will continue to plague western forests indefinitely.

OXFORD: 416.11; 453--145.718.28*

KEYWORDS: defoliation damage, tortricidae (-forest damage), western spruce budworm, outbreaks, host tree species, host tree impacts, biological control, chemical control.

CONTENTS

Douglas-fir forest devastated by the western spruce budworm, Helena National Forest, Montana.

INTRODUCTION

The western spruce budworm,[1] a conifer-feeding species, is one of the most widely distributed and destructive forest insects in western North America. Its presence here as a native insect pest has been known since the late 1800's from specimens collected by entomologists from farflung localities and later identified by insect taxonomists. However, no one reported epidemic infestations of the budworm until 1909 in British Columbia and 1922 in Idaho. In the past 50 years, many outbreaks[2] of the western spruce budworm have been reported in Rocky Mountain forests in stands of Rocky Mountain Douglas-fir (*Pseudotsuga menziesii* var. *glauca* (Beissn.) Franco), true firs (*Abies* spp.), Engelmann spruce (*Picea engelmannii* Parry), and western larch (*Larix occidentalis* Nutt.) in the American northern Rocky Mountain area, which roughly encompasses the Northern and Intermountain Regions of the USDA Forest Service.[3] Of even greater significance is the fact that visible defoliation caused by western spruce budworm infestations has been reported by at least one Ranger District in these two Forest Service Regions every year since 1922.

---

[1]*Choristoneura occidentalis* Freeman (Lepidoptera: Tortricidae) is a new species, established in 1967 (*47*) with the new common name, "western spruce budworm," which was adopted in 1970 (*7*). These names now apply to the insect formerly known in the Western United States as the spruce budworm, *C. fumiferana* (Clemens) and, prior to 1947, by the following generic and specific names: *Tortrix fumiferana* Clemens (1865), *T. nigrida* Robinson (1869), *Harmaloga fumiferana* (Clemens) (1913), *Archips fumiferana* (Clemens) (1929), and *Cacoecia fumiferana* (Clemens) (1943). Genetically and morphologically distinct from *C. occidentalis*, the spruce budworm, *C. fumiferana*, is a native insect pest of spruce and balsam fir forests in the Eastern United States and in Canada from the Maritime Provinces to the Yukon Territory. (In this paper, italicized numbers within parentheses refer to "References," numbers preceded by "U" refer to "Unpublished References.")

[2]Throughout this paper, *outbreak* designates a sudden large increase in population; *infestation* indicates a prolonged abnormally large population of the insect.

[3]Administrative Regions of the USDA Forest Service. The Northern Region (Region 1) includes 14 National Forests in northeastern Washington, northern Idaho, Montana, and northwestern South Dakota. The Intermountain Region (Region 4) encompasses 16 National Forests in southern Idaho, western Wyoming, Utah, a small portion of western Colorado, Nevada, and a small area in eastern California. These two administrative Regions are the geographic territory served by the Intermountain Forest and Range Experiment Station, which directs research programs on forest- and range-oriented problems.

Host tree defoliation and mortality throughout millions of acres of coniferous forests infested in these outbreaks have not been measured, but over the years they have been overwhelmingly visible. The effect of outbreaks upon the ecology, silvics, and management programs of the infested forests, likewise, has not been measured except by limited sampling in some areas; however, the effects are unpleasantly obvious to managers of these forest properties.

Research on the western spruce budworm in recent years has been concerned chiefly with its population dynamics, behavior, genetic characteristics, and chemical control. Few investigations have been directed specifically to its relationship with its host tree species or to the patterns of its outbreaks. Such studies must ultimately be made. Fortunately, much basic information useful for these studies exists in numerous reports that document details of the chronology, geographic distribution, and general severity of many of the budworm outbreaks in the two Forest Service Regions.

The general purpose here is to review this information (mostly unpublished) as a background for continuing biological and ecological studies of this important forest insect pest and as an appropriate reference for investigations into its epidemiology. Specifically, our intent here is to (1) consolidate, summarize, and present information about the location, host types, duration, effects, and measures for control applied in past outbreaks; (2) discuss factors that appear to relate to the location, duration, and probable effect of budworm outbreaks in the two Regions; and (3) identify problems for further study to more accurately assess the impact possibilities of outbreaks of the budworm in host forests managed for specific uses.

Hopefully, this presentation underscores the importance of the western spruce budworm problem in the northern Rocky Mountain region and will stimulate the development and application of management techniques to prevent or reduce intolerable resource losses from occasional or recurring epidemic populations of the insect.

Some interesting and important aspects and sidelights of past outbreaks are included herein for both their historical and their biological significance.

CHARACTERISTICS OF THE REPORTING AREA

Outbreaks of the western spruce budworm reported here occurred in National Forests, National Parks, or in extensive tracts of host type forests privately owned or managed by governmental agencies within the administrative boundaries of the Northern and Intermountain Regions of the USDA Forest Service. Boundaries of these two Regions are based chiefly on political subdivisions, but they show some minor ecologic and economic distinctions. Some tree species, for instance, are unique to one or the other Region. Climatic and physiographic differences produce varied silvicultural and mensurational characteristics that are bases for some differing management objectives.

Studies in biogeography and geomorphology provide some scientific identification of the distribution of the forest lands. Biogeography accounts for occurrence and distribution of floral and faunal communities; geomorphology accounts for the landforms.

Forests in the Northern and Intermountain Regions that are hosts to the western spruce budworm are mostly within the Northern Rocky Mountain and Central Rocky Mountain subregions of the Montana Coniferous Forest Biome described by Shelford (*84*), or the Northern Coniferous Forest Biome described by Odum (*77*). Exceptions are a few small, scattered, high-elevation forests of Douglas-fir, white fir (*Abies concolor* (Gord. and Glend.) Lindl.)), Engelmann spruce, and subalpine fir (*Abies lasiocarpa* (Hook.)(Nutt.)) that are isolated projections of this biome into an adjoining biome--Shadscale/Kangaroo Rat/Sagebrush (Cold Desert and Semidesert Communities)--in western Utah and Nevada (fig. 1). This biogeographic subdivision is the ecologist's way of recognizing major variations in the climatic climax vegetation that comprises the coniferous forests throughout the two Forest Service Regions.

Geomorphologists recognize basic differences in landforms within the Regions. In their classification, the two Regions are part of five contiguous geomorphologic, or physiographic, provinces characterized by uniform expressions of the topographic elements of altitude, relief, and type of landforms (*93*). The geography of the Northern and Intermountain Regions separates into these geomorphic provinces (fig. 2).

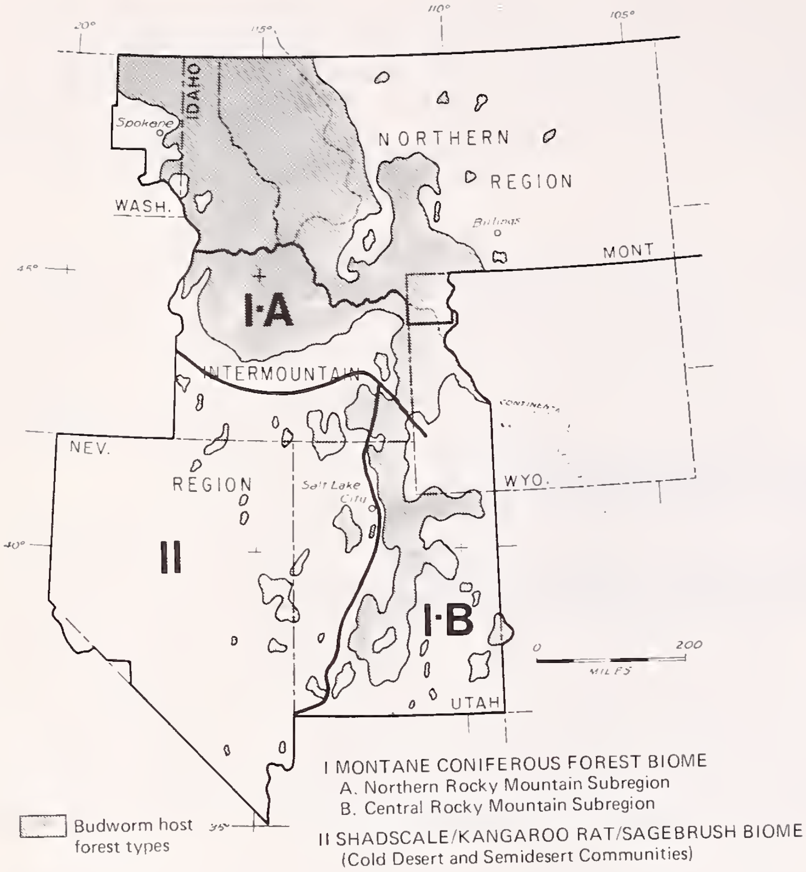


Figure 1.--Biogeographic (ecologic) biomes and subregions in the Northern and Intermountain Regions. (Adapted from Shelford 1963.)

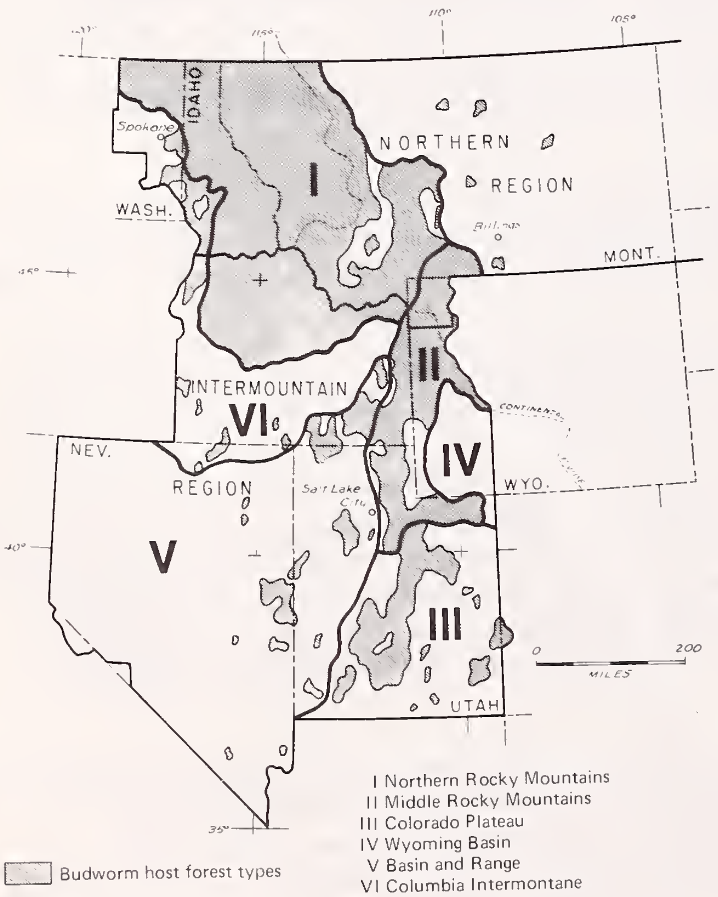


Figure 2.--Geomorphologic (landform) provinces in the Northern and Intermountain Regions. (Adapted from Thornbury 1965).

SOURCES OF INFORMATION ABOUT BUDWORM OUTBREAKS

The potential of the western spruce budworm for injuring and killing host trees began to be realized after several outbreaks of the insect in National Forests in northern Idaho and Montana during the 1920's. Growing concern over increasing depredations by this forest pest, heretofore not encountered in the northern Rocky Mountains, prompted National Forest administrators in both Regions to establish annual reports of budworm infestations beginning in 1925. That program has continued almost without interruption until the present and has provided one of the longest continuous records of epidemic infestations of a single forest insect pest to be found in the North American West.

Despite lack of complete scientific or political unity, the Northern and Intermountain Regions are treated here as a single reporting unit for budworm outbreaks. Responsibility for surveying the outbreaks and for evaluating, summarizing, and reporting the collected observations was divided between the Bureau of Entomology and Plant Quarantine[4] and the USDA Forest Service. Coordination of reports of outbreaks in both Regions was divided as shown below. Since 1961, reporting of insect conditions has been by the Division of State and Private Forestry in the Northern Region and by the Division of Timber Management in Intermountain Region. Despite this divided responsibility, there was interregional uniformity and continuity in developing techniques for detecting, evaluating, and documenting outbreaks that make joint consideration of budworm activities in the two Regions credible.

---

[4]The Bureau of Entomology was later named Bureau of Entomology and Plant Quarantine. When it was abolished in 1953, its insect studies and control activities and many of its personnel were assigned to the USDA Forest Service.

Region	*Timespan*	*Reporting source*
Northern	1925-1953	Annual surveys and reports of budworm infestations by National Forest district rangers; reports forwarded by Forest Supervisors to the Regional Office at Missoula, Mont., thence to the Bureau's forest insect laboratory at Coeur d'Alene for evaluating and summarizing.
	1948-1971	Annual surveys and reports of budworm infestations by entomologists of the Bureau's forest insect laboratory at Coeur d'Alene (1948-53); of the Intermountain Forest and Range Experiment Station at Coeur d'Alene (1954) and Missoula (1955-60); and of the Regional Office at Missoula (1961-71).
	1960-1969	Annual surveys and reports of budworm infestations in the Northern Region's Colville National Forest in northeastern Washington by entomologists of the Pacific Northwest Region (Region 6) at Portland, Oregon; by agreement between the two Regions.
Intermountain	1925-1951	Annual surveys and reports of budworm infestations by National Forest district rangers; reports forwarded by Forest Supervisors to the Regional Office at Ogden, Utah, for summarizing; thence to the Bureau's forest insect laboratories at Coeur d'Alene (1925-49) and Ogden (1950-51) for information.
	1950-1971	Annual surveys and reports of budworm infestations by entomologists of the Bureau's forest insect laboratory at Ogden (1950-53); of the Intermountain Forest and Range Experiment Station at Ogden (1954-60); and of the Regional Office at Ogden (1961-71).

A primary function of budworm surveys since 1925 has been to detect new outbreaks and to observe the progress of older active infestations. In most years, budworm surveys have examined outbreaks within National Forests and infestations of coniferous forests privately owned, or managed by Government agencies. Under this policy, entomologists from the Bureau of Entomology and Plant Quarantine or from the Forest Service have surveyed budworm infestations in Glacier and Yellowstone National Parks as part of their annual activity. Similarly, they have annually surveyed forests managed by the Bureau of Land Management, the Bureau of Indian Affairs, the Army Corps of Engineers, and forests owned by large lumber companies in Idaho and Montana.

Reports of the numerous extensive outbreaks of the budworm from 1922 through 1971 produced a cumulate record of destruction by a single forest insect pest that is unmatched. The record is unique for the mass and continuity of its collected information and for the great number of foresters and forestry technicians who collected this information during the first 30 years of this reporting. During the following two decades (roughly 1953-1971), an even greater amount of diverse information about outbreaks and continuing infestations was developed from the annual effort of fewer entomologists and foresters, who were using more sophisticated techniques and equipment for their surveys.

Annual surveys and reporting of budworm outbreaks were started in 1925 primarily because three men shrewdly recognized the destructive capabilities of the budworm in many forests on the northern Rocky Mountains. These men were James C. Evenden, Entomologist-in-Charge of the Bureau of Entomology's forest insect laboratory at

Coeur d'Alene, Idaho; and Elers Koch and R. H. Rutledge, District (now Regional) Foresters of the Northern and Intermountain Regions of the USDA Forest Service, headquartered at Missoula, Montana, and Ogden, Utah, respectively.

The dedicated performance of scores of National Forest District Rangers and their staffmen are responsible for success of the program of budworm surveys that continued for nearly 30 years. Their work in locating and determining the extent of outbreaks was arduous and time-consuming. Rugged terrain and lack of roads in most ranger districts denied them easy access to many outbreak areas. So these men viewed and mapped the expanse of many budworm-infested forests from vantage points on mountaintops and ridges frequently accessible only by laborious travel on foot or on horseback. Building roads into these remote areas later made it fairly easy to travel into infested forests and examine damage. These on-the-ground surveys were expensive in time and manpower, but results obtained by them compare favorably with results achieved by the refined methods used in insect surveys today.

Much present-day knowledge about budworm outbreaks and continuing infestations is available only because of the physical endurance and keen perception of those early rangers and technicians. Since so much of the information published here was available only from reports of specific outbreaks furnished by these men, we have identified each man by name wherever possible and have detailed their significant findings in tables 4, 5, and 6.

In 1948, the Bureau of Entomology and Plant Quarantine undertook responsibility for developing and conducting regionwide surveys of budworm infestations on all forested lands irrespective of ownerships. The first survey under this new sponsorship was made in Montana that year (*U107*). The reporting of budworm outbreaks by National Forest District Rangers was gradually phased out and was terminated in both Regions by 1953.

During this transitional period, entomologists of the Bureau explored the use of airplanes for surveying budworm outbreaks and for monitoring the performance of airplanes used for spraying chemical insecticides to control epidemic populations. Robert E. Denton and Tom T. Terrell in Missoula and Walter E. Cole in Boise, Idaho, developed the technology that established safe, effective use of airplanes for both spraying and monitoring (*U40, U215, U24*).

By 1955, entomologists throughout the northern Rockies were regularly using small well-powered airplanes to locate new outbreaks, to map their extent and that of continuing infestations, and to delineate outbreaks and existing infestations by relative intensities of host forest damage. The problems initially encountered with airplane performance, pilot skills, and observer proficiency had been largely overcome (*U48, U24*).

EARLIEST RECORDED OUTBREAKS

J. A. Fitzwater, Supervisor of the Kaniksu National Forest, headquartered at Newport, Washington, reported the first known outbreak of the western spruce budworm in this area in January 1922 from Kalispell Bay on Priest Lake in northern Idaho (*36, 37, 38, U60*). Fitzwater reported the dying of western hemlock, presumably from attack by an insect not yet identified.

In June 1922, Henry J. Rust, Entomological Ranger at the Forest Insect Laboratory in Coeur d'Alene, Idaho, collected feeding larvae from infested hemlock in the outbreak area. At the same time, he collected similar larvae from severely defoliated western larch, western redcedar (*Thuja plicata* Donn), grand fir (*Abies grandis* (Dougl.) Lindl.), western white pine (*Pinus monticola* Dougl.), and Engelmann spruce in the same general area. Specimen adults reared from these larvae at the Coeur d'Alene laboratory were identified by Carl Heinrich, a taxonomic specialist in the Bureau of Entomology, Washington, D.C., as *Harmologa fumiferana* Clemens. In response to the suggestion[5] that the Priest Lake outbreak might be the first to be recorded for this insect in the West, Heinrich wrote:

> It is somewhat doubtful how long the budworm has been working in the West, but inasmuch as it is an American insect, it is quite likely that it has been present there a long time. It is now known from British Columbia to the Southwest and most everywhere that hemlock and spruce occur.

Heinrich's reference to the geographic distribution of the budworm presumably was based upon specimens of the insect collected from locations throughout the Western United States and Canada rather than from reported outbreaks. In fact, outbreaks of the spruce budworm had been reported as early as 1907 on "spruce trees in Manitoba" and in 1909 in forests of Douglas-fir near Victoria and Duncan on Vancouver Island, British Columbia (*51*). There is some doubt whether the insect reported in the 1907 "spruce trees in Manitoba" was mistaken for the eastern form of the budworm, *Choristoneura fumiferana*, or whether this was indeed the western form, *C. occidentalis*.

Yellowstone National Park in Wyoming, Idaho, and Montana was the site of one of the earliest outbreaks of the western spruce budworm in stands of Rocky Mountain Douglas-fir in the Blacktail Deer Creek basin. Entomologists ascertained that the infestation, first reported in 1923, had persisted since about 1919 (*U19*).

During the years that followed the report of the initial budworm outbreak at Priest Lake, forestry personnel submitted numerous reports of additional budworm outbreaks from widely scattered localities within National Forests of the area and from Yellowstone National Park (table 1). Millions of acres of host forests felt the destructive impact of budworm outbreaks in subsequent years--extensive damage that earned the budworm its present reputation as a formidable forest pest.

---

[5]By James C. Evenden, Entomologist-in-Charge, Coeur d'Alene Forest Insect Laboratory.

SALIENT FEATURES OF OUTBREAKS

Chronology

Annual reports of forest insect conditions prepared by National Forest ranger districts ably documented the sequence of budworm outbreaks in Montana and northern Idaho from 1925 to 1953. Ranger district reports of active infestations (table 2) revealed that the insect was most active in the Clearwater and Nezperce National Forests in Idaho and in the Beaverhead, Deerlodge, Flathead, Gallatin, Helena, Lewis and Clark, and Lolo National Forests in Montana. Despite having vast areas of possible host forests, the Colville National Forest in Washington reported no budworm outbreaks; and the remaining National Forests in Idaho and Montana harbored only a few widely scattered outbreaks.

The year-to-year prevalence of the budworm during this early period was particularly evident in the Nezperce National Forest in Idaho and in the Gallatin and Helena National Forests in Montana. The Townsend ranger district of the Helena National Forest has reported active infestations of the budworm within its borders every year since 1925, a record unequaled elsewhere in the two Regions.

During the early budworm infestations in the 1920's and early 1930's, outbreaks occurred almost annually in the Boise and the Payette (then Weiser) National Forests in west central Idaho. Outbreaks were reported less frequently from the Challis (then Lemhi) and Sawtooth National Forests in this same general area and from the Bridger and Teton National Forests in western Wyoming and the Targhee National Forest in eastern Idaho.

No significant budworm outbreaks were reported anywhere in the Intermountain Region from the early 1930's until about 1950.

The budworm's potential as a forest insect pest prompted both Regions to inaugurate systematic annual surveys of outbreaks in 1950 to accurately map their extent and to assess their impact on the infested host forests. Survey techniques and reporting standards were established, and entomologists were especially trained to use aerial surveillance.

On the ground, entomologists of both Regions observed and measured the nature and severity of defoliation (*U179*). Both in the field and in the laboratory they used specific biological techniques to measure the density of current budworm populations and to predict any changes in this density for the following year (*U43, U218*). Reports based on these surveys provide a detailed account of the location, extent, and relative severity of host forest defoliation or tree mortality caused by the budworm in the Northern Region since 1948 (*U107*) and in the Intermountain Region since 1950 (*U185*). The information in these reports, presented by States and National Forests or other forest management units, makes it possible to pinpoint the location of active budworm infestations each year.

In the Northern Region, for instance, entomologists' reports disclosed that 11 of 16 National Forests sustained budworm outbreaks in host stands for most of the years between 1948 and 1956 and between 1960 and 1971 (table 3). Similar frequency of outbreaks during these years was reported from Yellowstone National Park and a large tract of private timberland on Craig Mountain southeast of Lewiston, Idaho. The greatest number of outbreak years was reported from 7 of 10 National Forests in Montana, from the Clearwater and Nezperce National Forests in Idaho, and from Yellowstone National Park. Only the Coeur d'Alene National Forest in Idaho and the Kootenai National Forest in Montana were free of recorded budworm outbreaks during the 1948-1971 period.

Outbreaks were reported similarly in the Intermountain Region for 22 years beginning in 1950. Six of that Region's National Forests reported outbreaks almost annually (table 3), whereas surveys disclosed that outbreaks in other National Forests in the Region were infrequent.

The chronology of outbreaks of the western spruce budworm in National Forests and other public lands in this area can also be determined from the information in tables 4, 5, and 6 for the period 1922 to 1953, and in tables 7 and 8 for the period 1948 to 1971.

Information is scant on outbreaks that may have occurred prior to 1950 in extensive tracts of privately owned host type forests in Idaho and Montana. Since then, Forest Service annual surveys of budworm outbreaks have covered these tracts, and all publicly owned forest land outside of National Forests and National Parks.

Host Tree Species

The most frequently reported hosts of the western spruce budworm in the Northern and Intermountain Regions are these six species:

Rocky Mountain Douglas-fir
Pseudotsuga menziesii var. *glauca* (Beissn.) Franco;

Grand fir
Abies grandis (Dougl.) Lindl.;

Engelmann spruce
Picea engelmannii Parry;

Subalpine fir
Abies lasiocarpa (Hook.) Nutt.;

Western larch
Larix occidentalis Nutt.; and

White fir
Abies concolor (Gord. & Glend.) Lindl.

General distributions of these species are shown in figure 3. Patterns of distribution for Douglas-fir, spruce, and subalpine fir are strikingly similar throughout their range. Spruce and subalpine fir often occupy the same high-elevation sites, but are separated from Douglas-fir stands by such physiographic features as topography, exposure, elevation, precipitation, or air temperature. Forests of grand fir, western larch, and white fir are more restricted in their distribution, but they fit within the broader distributions of the three species just mentioned.

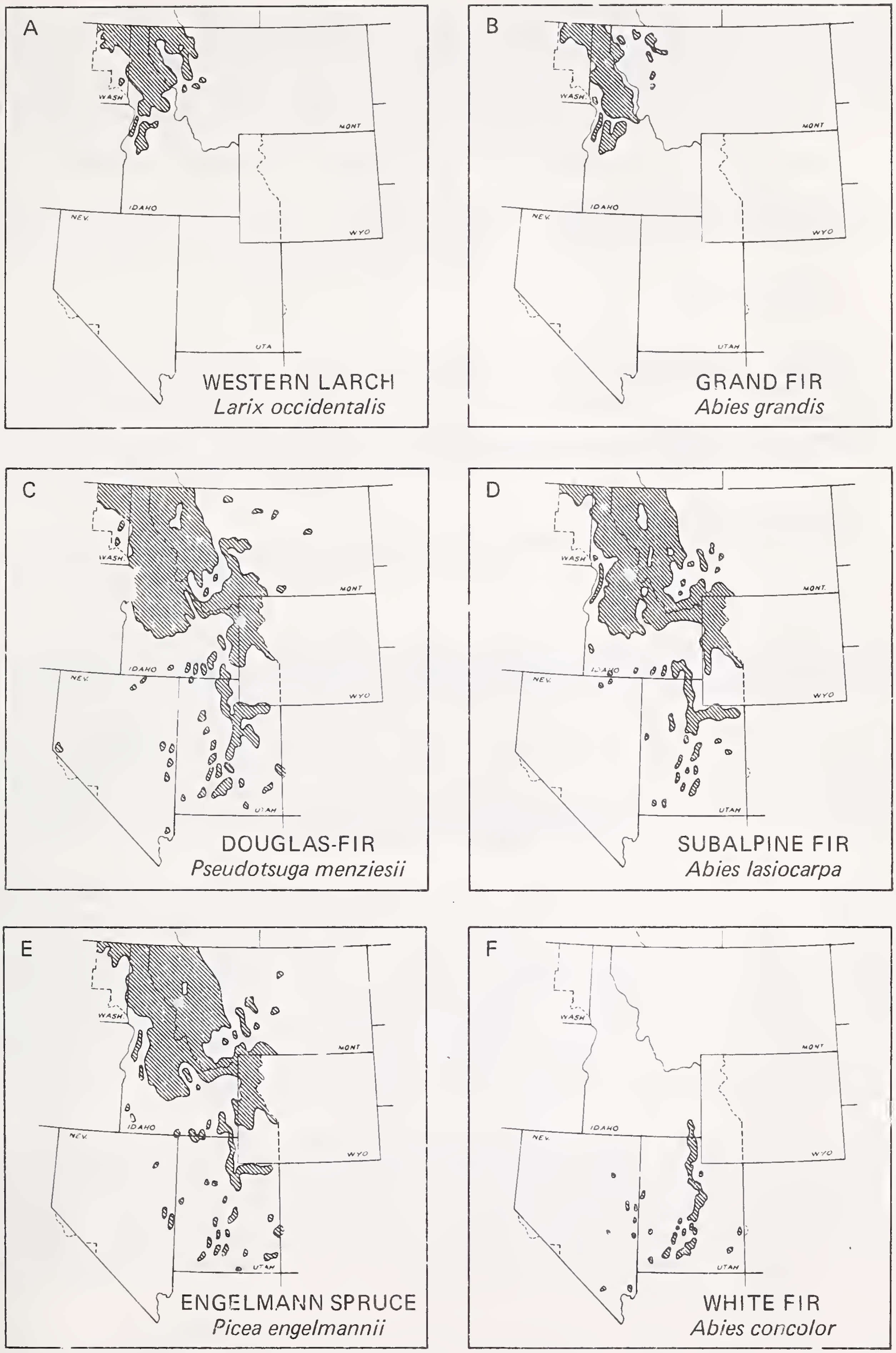


Figure 3.--Distribution of major host species for the western spruce budworm in the Northern and Intermountain Regions. (From Fowells 1965.)

Combinations of the six major budworm host species named above occur frequently in some localities: Douglas-fir and grand fir in northern Idaho; Douglas-fir and western larch in western Montana; and Engelmann spruce with subalpine fir at the higher elevations in both States. Only Douglas-fir grows extensively in pure stands, principally in central Idaho and in Montana mostly east of the Continental Divide.

Six additional coniferous species are occasional hosts of the budworm:

Ponderosa pine
Pinus ponderosa Laws.;

Lodgepole pine
Pinus contorta Dougl.;

Western white pine
Pinus monticola Dougl.;

Western hemlock
Tsuga heterophylla (Raf.) Sarg.;

Mountain hemlock
Tsuga mertensiana (Bong.) Carr.; and

Western redcedar
Thuja plicata Donn

Use of the foliage of these trees for food is survival behavior of budworm larvae when foliage from preferred trees is no longer available.

Reports in 1929 and 1930 attributed extensive defoliation of lodgepole pine forests in Yellowstone National Park to the budworm (*U14, U15*); recently that defoliation has been determined to have been caused by another budworm, *Choristoneura lambertiana* Freeman, a pest of several species of pine in the northern Rocky Mountain area.[6] Upon first examination, the two species appear quite similar.

Most outbreaks of the budworm have been reported from forests of Douglas-fir in Montana, Yellowstone National Park (Wyoming, Idaho, and Montana), south central and eastern Idaho, western Wyoming, Utah, and northeastern Nevada. Other host forest types, however, have supported some significant outbreaks of the insect: (1) mixed forests of Douglas-fir and grand fir in northern Idaho, where both tree species often serve simultaneously as hosts; (2) forests of pure Engelmann spruce in Glacier National Park, Montana; (3) mixed forests of Engelmann spruce and subalpine fir, where both species usually serve together as hosts; and (4) quite recently, in pure forests of young western larch in western Montana, which are mostly in plantations.

Defoliation of western larch by the budworm has been reported occasionally in the last 50 years in this area. The importance of larch as a host for the budworm was enhanced in the early 1960's when the insect was found damaging or destroying cones and seeds on older larch trees and severing the stems of terminal and lateral shoots of young western larch trees (*42, 83*) Since then, stem severing by feeding larvae has been found in western Montana wherever populations of the budworm are epidemic in stands of seedling, sapling, or pole-size western larch.

---

[6]Personal correspondence from T. N. Freeman, Insect Taxonomist, Entomology Research Institute, Ottawa, Ontario, Canada, December 18, 1968.

Identity of major host species and frequency with which each species was infested were determined chiefly from the annual reports of budworm outbreaks prepared by National Forest District Rangers in the Northern Region from 1925 to 1953 (table 9). Douglas-fir was by far the most frequently reported host tree species; it was followed successively by grand fir, Engelmann spruce, subalpine fir, and western larch. White fir (*Abies concolor*) does not grow in the Northern Region.

Lodgepole pine was noted as a budworm host in several ranger district reports. From present knowledge, we cannot determine whether lodgepole pine was an accidental host of the budworm or a major host of the pine-infesting *Choristoneura lambertiana* in the same area. Most likely, it was the latter.

Western hemlock and western redcedar are not included in table 9 even though both species were hosts in the first budworm outbreak reported in northern Idaho in 1922. Host tree species mentioned in specific outbreaks described in the District Ranger reports from 1925 to 1953 are included in table 4. Host species in outbreaks in Glacier and Yellowstone National Parks and in the Intermountain Region between 1922 and 1964 are listed in tables 5 and 6, respectively.

We first observed defoliation of mountain hemlock by the budworm in the Clearwater National Forest in the summer of 1972.

Many forests containing host tree species acceptable to the budworm are known to be uninfested. Among them are those in northeastern Washington, in Idaho generally north of the St. Joe River, in Montana generally north and west of Flathead Lake, as well as some in Utah and Nevada.

Geographic Distribution

Many reports of budworm outbreaks submitted by District Rangers from 1925 through 1953 included maps of infested areas (fig. 4). Because many reports did not include such maps, cartographic representations of the outbreaks are not possible. However, we can picture the geographic distribution of budworm outbreaks in the Northern Region during these years by arranging the reporting National Forests and ranger districts in a schematic format, as in tables 10 and 11. In this arrangement, each ranger district receives equal value as an area of infestation regardless of the infested acreage it reported. These tables show that (1) budworm outbreaks covered significant areas in the present-day Clearwater and Nezperce National Forests from 1926 to 1933, (2) outbreaks persisted in one or two ranger districts in the Helena National Forest during the entire period from 1925 to 1953, and (3) short-lived outbreaks appeared in some ranger districts in a few National Forests widely scattered throughout the Region during this period.

In the Intermountain Region during this same period, similar but less frequent ground surveys by District Rangers disclosed outbreaks of the budworm primarily in the Boise and present-day Payette National Forests and only sporadic, brief outbreaks in other widely separated National Forests. This Region reported no significant outbreaks of the budworm from the early 1930's until 1950.

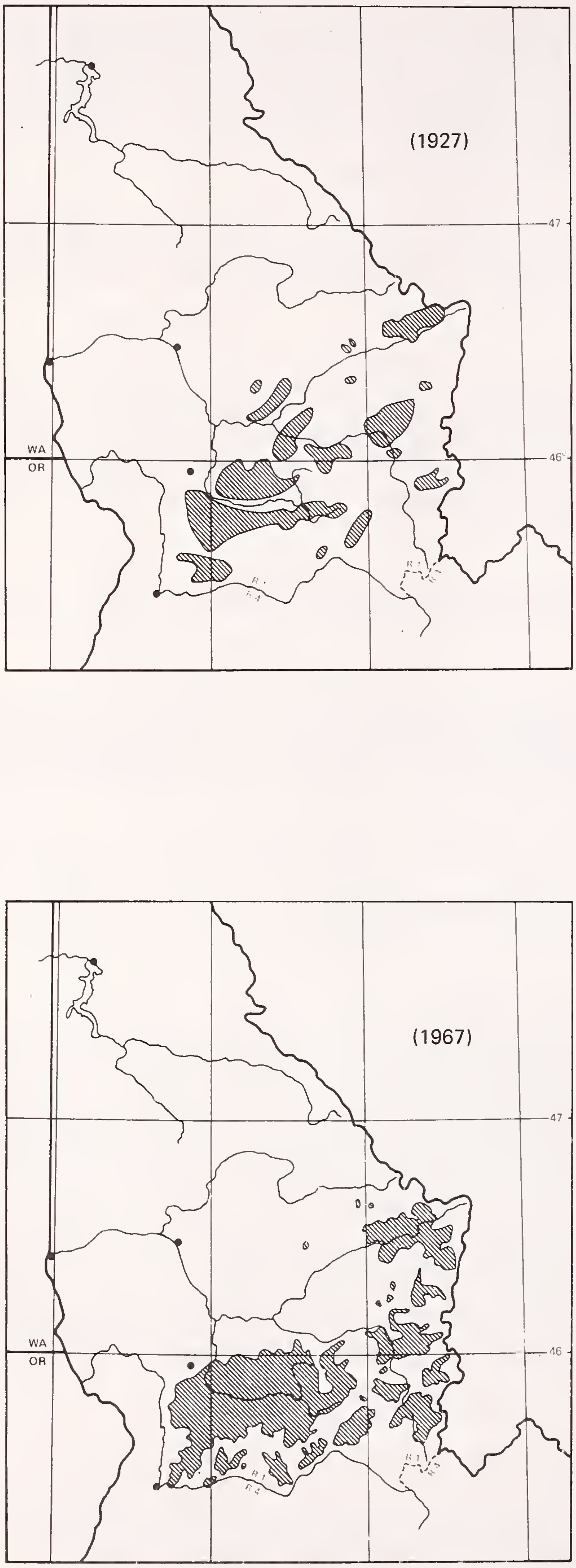
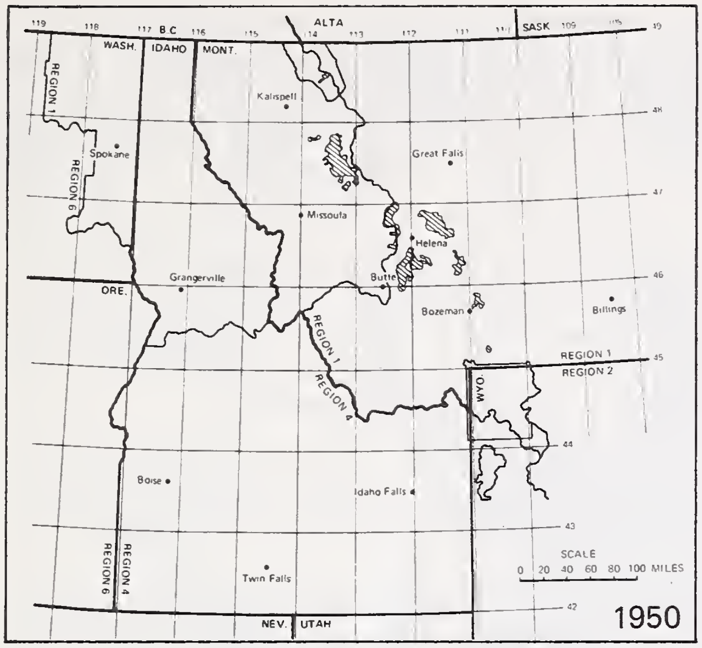
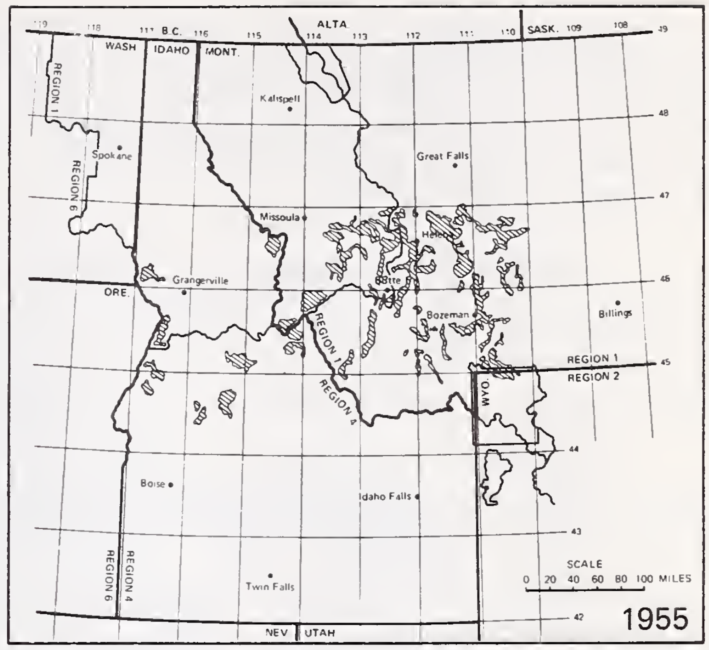
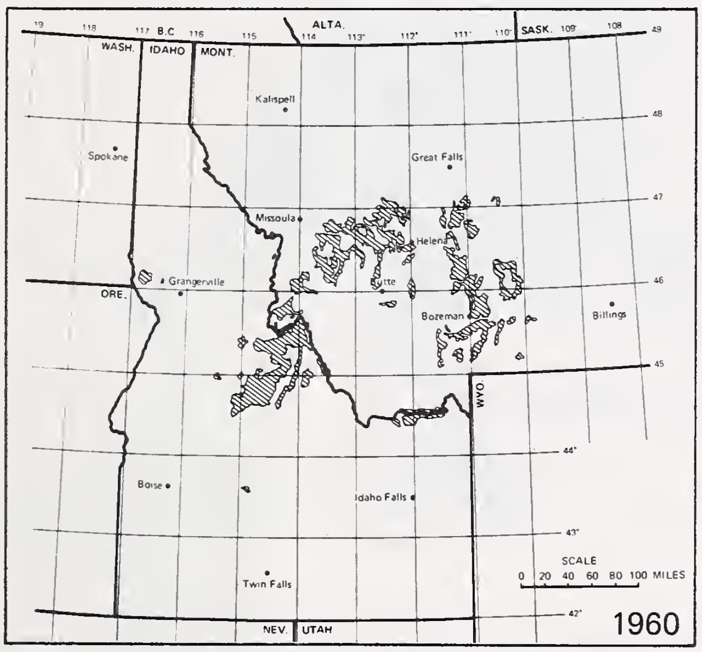
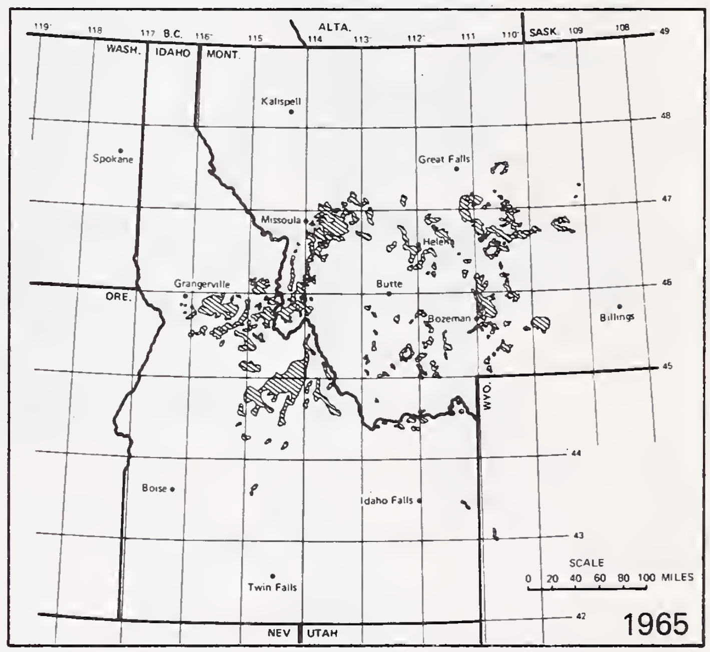


Figure 4.--Similarity in geographic distribution of outbreaks of the western spruce budworm in the Northern Region, 1927 and 1967.









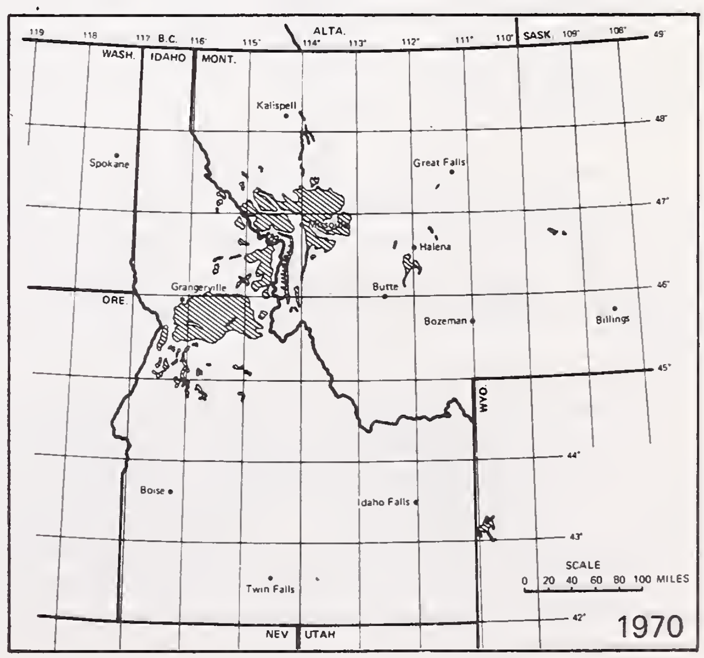


Figure 5.--Distribution patterns of aerially visible forest defoliation by the western spruce budworm in the Northern and Intermountain Regions at 5-year intervals, 1950-1970.

Brown (*13*) depicted the changing pattern of widespread budworm outbreaks in eastern Canada over a span of time with the aid of a cartographic series that plotted the position and shape of infestations annually or periodically from 1909 to 1966. A similar representation of outbreaks of the western spruce budworm in the Northern and Intermountain Regions (fig. 5) identifies several distinguishable patterns of distribution between 1948 and 1971:

1. Outbreaks predominantly in forests of pure Rocky Mountain Douglas-fir in Montana east of the Continental Divide, and west of the Divide in extensions of this host type, from 1948 to 1966 (Beaverhead, Custer, Deerlodge, Flathead (in part), Gallatin, Helena, and Lewis and Clark National Forests; in the Garnet Range east of Missoula, Mont., in lands administered by the Bureau of Land Management).

2. Outbreaks in western Montana in forests of mixed Rocky Mountain Douglas-fir, western larch, and ponderosa pine, from 1966 to 1971 (Bitterroot and Lolo National Forests).

3. Proliferation of outbreaks in northern Idaho in forests of mixed grand fir and Rocky Mountain Douglas-fir, both serving as hosts, from 1966 to 1971 (Bitterroot, Clearwater, and Nezperce National Forests).

4. Geographically stable outbreaks, but with fluctuating intensities from 1954 to 1971 in west central Idaho (Boise, Challis, Payette, Salmon, and Sawtooth National Forests) and in the eastern Idaho-western Wyoming area (Targhee, Bridger, and Teton National Forests).

These aerial survey-based representations show that budworm outbreaks in the Northern Region have undergone some massive displacement, while those in the Intermountain Region have remained in essentially the same geographic locations in recent years.

Area of Defoliated Forests

The area of defoliated host forests is one of several measurable data used to describe the damage from specific budworm outbreaks. Area is often used as the sole measure, probably because it is quite easily obtained and is the datum most frequently provided by aerial surveys of infested forests.

In northern Idaho and in Montana, reports of budworm outbreaks submitted between 1922 and 1953 often estimated the gross acreage of defoliated forests (tables 4 and 5). Some contained maps delineating the defoliated areas; these substantiated the estimates. However, these reports cannot be used to compute Regionwide estimates of the acreage of budworm-infested forests for each year of the reporting period.

Estimates of areas of defoliated forests and other descriptive data in the reports strongly indicate that at least 750,000 acres of Douglas-fir and grand fir forests were defoliated in 1930, the year when budworm outbreaks in northern Idaho between 1926 and 1933 apparently reached their maximum intensity. Most of this defoliated acreage was concentrated in the present-day Clearwater and Nezperce National Forests.

Estimates of acreage of budworm-defoliated forests have been computed yearly from aerial surveys of infested areas conducted since 1950 in the Northern Region and since 1954 in the Intermountain Region. From a low of 270,000 acres in 1948 (estimated from an intensive ground survey), single-year estimates of budworm-defoliated forests soared to nearly 4.9 million acres in 1958 and 1959 in the Northern Region and to 2.3 million acres in 1964 in the Intermountain Region (table 12). These single-year estimates do not reveal the cumulative acreage of host forests defoliated in each Region over the total reporting period.

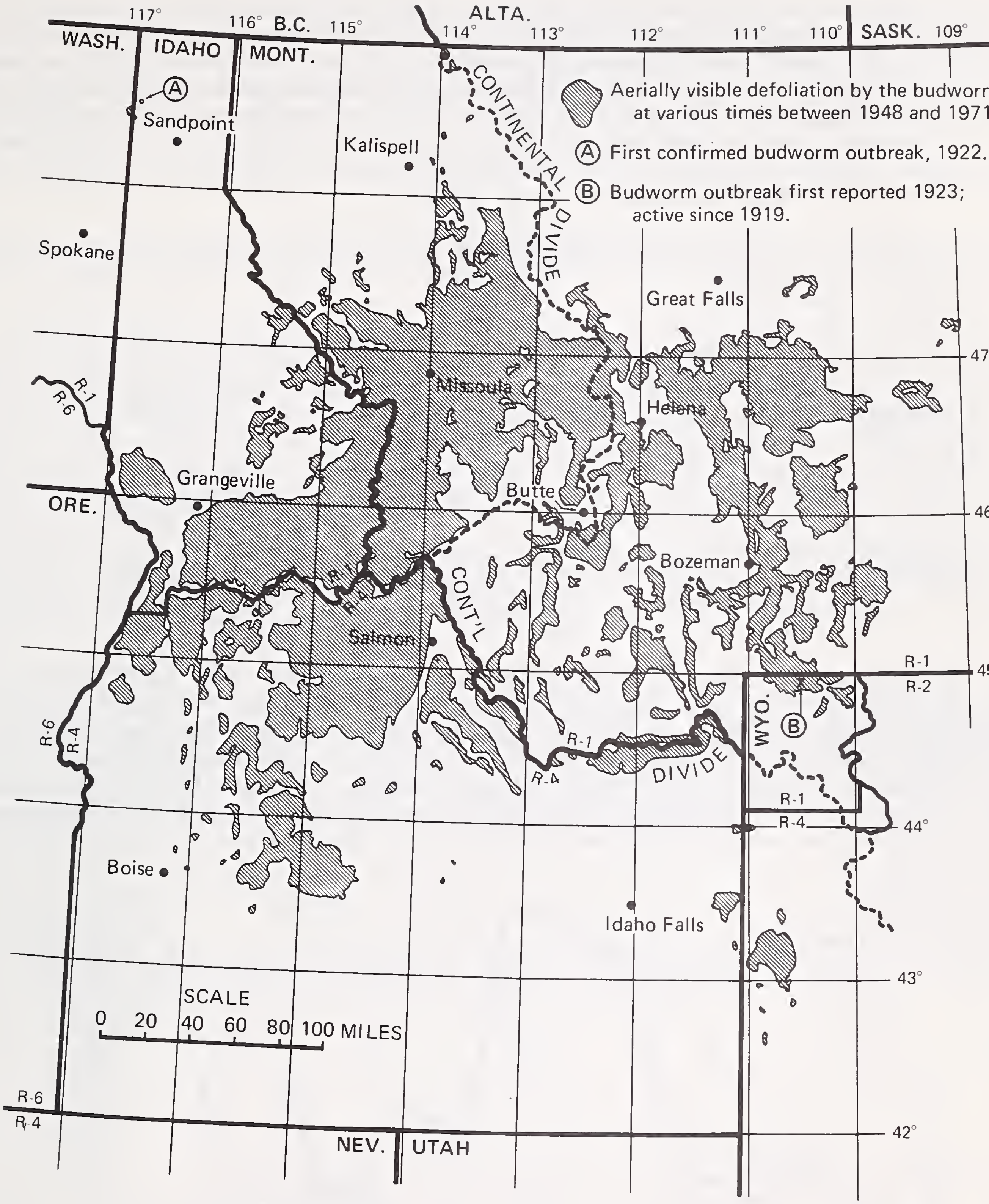


Figure 6.--Areas of major host types defoliated by the western spruce budworm in the Northern and Intermountain Regions at various times between 1948 and 1971. Few host forests within the general area of defoliation shown here escaped the damaging presence of the budworm at some time during the 24-year period. Interspersed among the defoliated forests are vast areas of forests immune to the budworm or nonforested lands. In contrast, extensive forests of several primary host species were not infested by the budworm during the period; notably those in the northwest corner of Montana, Idaho's panhandle, and in northeastern Washington. Neither was the budworm reported from most of the scattered host stands of Douglas-fir, Engelmann spruce, and subalpine and white fir in Nevada, Idaho south of the Snake River, western Wyoming, and Utah during the same period.

It is important to know how large an area in host forests had been invaded by the budworm to fully evaluate the effect of the insect on this resource. Consequently, the total acreage of host forests epidemically infested in each Region has been determined here by constructing a composite map of the outlines of defoliated forests (fig. 6). Computed gross acreages of all infested forests thus outlined were then reduced by one-third, a correction factor found necessary to eliminate reasonably consistent intermingled areas of nonhost forests or of nonforested lands too small to be feasibly mapped by aerial observers surveying outbreak areas (*U235*).

The technique described above has revealed that the net acreage of forests epidemically infested by the budworm for 1 or more years in this area is truly great, as shown in the following tabulation:

Region	*Reporting period, inclusive*	*State*	*Net infested acreage*
Northern	1948-71	Northern Idaho	1,912,350
		Montana	8,209,900
			10,122,250
Intermountain	1954-71	Southern Idaho	4,408,730
		Wyoming	180,430
			4,589,160

On the basis of the area of visible defoliation reported, five major cycles of budworm outbreak can be identified since 1926. The chronology and general location of the cycles are shown in table 13; figure 7 graphically portrays these infestations in terms of total acreage of host forests each one covered. Budworm outbreak cycle I, which persisted in northern Idaho between 1926 and 1933, was identified from annual reports of forest insect conditions by National Forest District Rangers. Absence of estimates of infested acreage from many reports precluded the plotting of this outbreak cycle in figure 7.

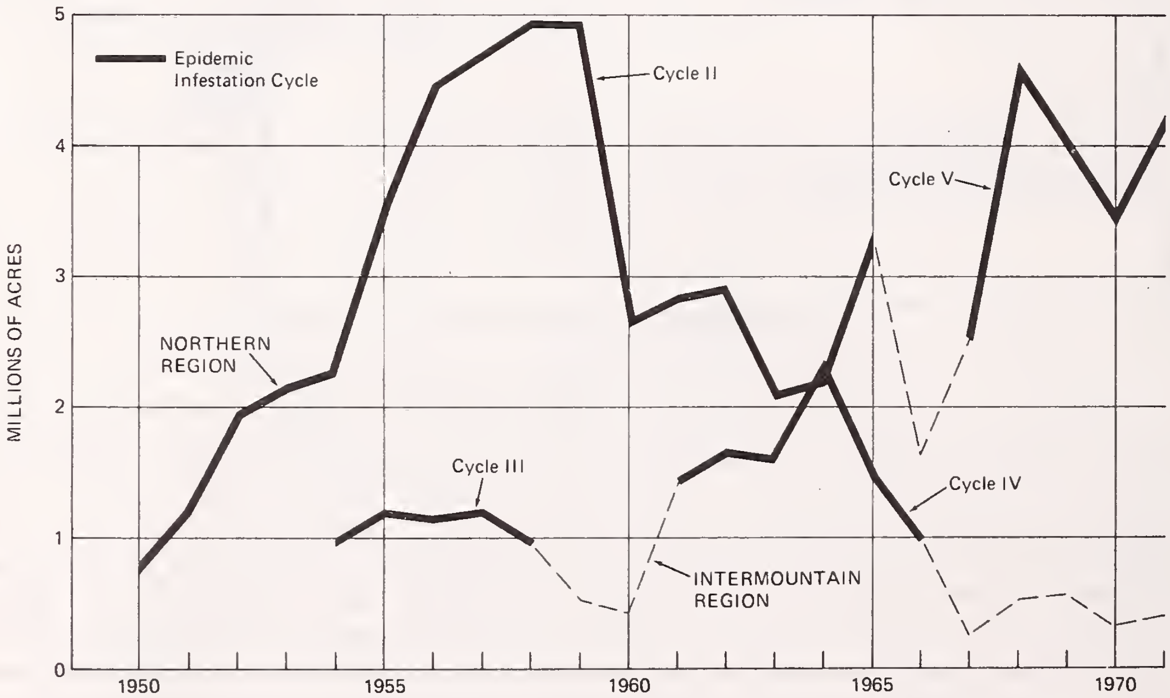


Figure 7.--Cycles of outbreaks of the western spruce budworm in the Northern and Intermountain Regions as determined from annual fluctuations in acreage of aerially visible defoliation. (Cycle I occurred in 1928-1933 (see table 13)).

Three cycles involved host forests in Idaho, but the single outbreak cycle in Montana (cycle II) continued longer and devastated more host forests. The fifth, and current, outbreak cycle extends from western Montana into northern Idaho and has already seriously defoliated many Douglas-fir and grand fir forests infested during cycle I. The ultimate damage to these forests from cycle V cannot be determined until it has run its course.

Duration

Visible budworm-caused defoliation and densities of budworm populations have not been measured for the express purpose of determining the longevity of any budworm infestations in this area. Some epidemic populations of the insect have been estimated in certain years to establish the need for chemical control of infestations the following year (*U218, U219*) or to predict the trend of other infestations (*U224, U238*). Such population estimates occasionally confirmed the beginning or ending of some outbreaks, but they lacked the needed year-to-year continuity to pinpoint both the beginning and ending dates that would establish duration. Many population estimates made as part of biological evaluations of budworm outbreaks, consequently, have not contributed much toward precise knowledge of duration of the insect's outbreak. For practical purposes, the period between the first and last appearances of visible defoliation is the most dependable criterion of budworm outbreak duration over large areas.

Nevertheless, the many reports of budworm activities in this mountain country contain clues to persistence of outbreaks. One is in the annual reporting of outbreaks in National Forest ranger districts and in Glacier and Yellowstone National Parks from 1922 to 1953, summarized in table 2. Recapitulation of the data in that table identifies 82 budworm outbreaks and indicates their duration as follows:

Duration of outbreak	*Idaho*		*Montana*		*Wyoming (Yellowstone National Park)*	
(Years)	*(Number)*	*(Percent)*	*(Number)*	*(Percent)*	*(Number)*	*(Percent)*
1-5	15	60	42	76	1	50
6-10	9	36	10	18	1	50
11-15	1	4	2	4		
16-20						
21-25						
26-30			1	2		
	25	100	55	100	2	100

This tabulation shows that most budworm outbreaks in northern Idaho and Montana between 1922 and 1953 lasted from 1 to 5 years.

Information in table 2 does not indicate that budworm infestations persist longer in the more humid environment of the grand fir--Douglas-fir of northern Idaho or in the drier environment of pure Douglas-fir forests east of the Continental Divide in Montana and in Yellowstone National Park. However, the longest consecutive reporting of budworm infestation was in this latter zone.

A further clue to the duration of budworm outbreaks is apparent from examination of the geographic distribution of aerially visible defoliation of host forests each year. Maps that outlined the Regionwide distribution of budworm-defoliated forests were prepared annually from 1948 to 1964 in the Northern Region and from 1954 to 1968 in the Intermountain Region. Superimposing the maps one at a time on a light-transmitting table enabled drawing of overlay tracings that outlined areas defoliated for 1 year and those continuously defoliated for 2 or more years.

The net acreage[7] of host forests defoliated during budworm outbreaks of varying durations was calculated by this method:

Duration of outbreak	*Northern Region*		*Intermountain Region*	
(Years)	*(Net acreage)*	*(Percent)*	*(Net acreage)*	*(Percent)*
1-5	4,838,030	69.6	4,037,190	88.2
6-10	1,490,390	21.5	359,850	7.9
11-15	598,700	8.6	178,610	3.9
16-20	20,380	0.3		

Dendrochronological techniques have successfully dated past outbreaks of the spruce budworm in the Eastern United States and Canada (*23*, *5*, *6*). Radial increment patterns are also being evaluated in the Northern and Intermountain Regions to date budworm outbreaks in relation to occurrence of various environmental influences or to measure the impact of outbreaks on the growth rates of budworm-defoliated trees.[8]

It is more difficult to use dendrochronological patterns to estimate duration of budworm outbreaks in the two western Regions than in the East because several other catastrophic defoliating arthropods, pathogens, and climatic phenomena are present in host and nonhost forests. Defoliation resulting from occasional and often persistent occurrence of these other agents can and does obscure defoliation caused by the budworm. This masking by other agents frequently prevents valid comparisons between radial growth patterns of infested and noninfested host trees and between those of infested host trees and nonhost tree species.

---

[7]Net acreage is presumed to be approximately two-thirds of the gross acreage of defoliated forests aerially mapped during budworm surveys, to account for areas of nonhost forests and nonforested lands.

[8]Richard I. Washburn and William H. Klein, Principal Entomologist and Associate Entomologist, respectively, Intermountain Forest and Range Experiment Station, Moscow, Idaho, and Division of Timber Management, Intermountain Region, Ogden, Utah. Personal communications.

Defoliating agents on conifers include:

Agents	*Host tree species*	*Region of greatest occurrence*
Insects		
Black-headed budworm (*Acleris variana* Fernald)	DF,WH,ES,SF[1]	Northern
Lodgepole needle miner (*Recurvaria milleri* Busck)	LPP	Intermountain
Douglas-fir tussock moth (*Hemerocampa pseudotsugata* McDonnough)	DF,GF,ES	Nor./Int.
Spruce cone worm (*Dioryctria reniculella* (Grote))	DF	Nor./Int.
Larch casebearer (*Coleophora laricella* (Hübner))	WL	Northern
Larch sawfly (*Pristiphora erichsonii* (Hartig))	WL	Nor./Int.
Pine butterfly (*Neophasia menapia* (Felder & Felder)	PP	Nor./Int.
Sugar pine tortrix (*Choristoneura lambertiana* (Busck))	LPP,PP	Nor./Int.
Lodgepole sawfly (*Neodiprion burkei* Middleton)	LPP	Northern
Mites		
Spruce spider mite (*Oligonychus ununguis* (Jacobi))	DF	Nor./Int.
Diseases		
Dwarf mistletoe (*Arceuthobium* spp.)	DF,WL,PP,LPP	Nor./Int.
Needlecast fungi		
(*Rhabdocline pseudotsugae* Sydow)	DF	Nor./Int.
(*Elytroderma deformans* (Weir) Darker)	PP	Northern
(*Hypodermella laricis* Tubeuf)	WL	Nor./Int.
(*Lophodermella concolor* (Dearn.) Darker)	LPP	Northern
(*Meria laricis* Vuill.)	WL	Nor./Int.
Climatic		
"Red belt" winter drying	DF,PP,LPP	Nor./Int.
Extended drought	All	Nor./Int.

[1] Abbreviations of names of tree species here and elsewhere are: DF, Douglas-fir; GF, grand fir; SF, subalpine fir; ES, Engelmann spruce; PP, ponderosa pine; LPP, lodgepole pine; WL, western larch; WH, western hemlock.

Dendrochronological determination of duration of budworm outbreaks is further hampered in this area by (1) the absence, for tree ring comparisons, of nonhost tree species from many infested forests; (2) the lack of weather recording stations in the intimate forest environment which would indicate the microclimate and its effect on tree growth patterns in the abrupt mountain terrain that supports most budworm-susceptible forests; or (3) the possible arrest of declining radial increment in trees heavily defoliated by prolonged budworm infestation as epicormic branching develops, as spatial competition lessens following the budworm killing of nearby trees, or as infesting budworm populations were destroyed by large-scale aerial spraying of pesticides periodically in both Regions from 1952 through 1956.

Evidence indicates that most outbreaks of the western spruce budworm appear to persist naturally from 1 to 5 years. Outbreaks lasting to 10 or more years occur occasionally, and a few have continued even longer.

Factors Influencing Population Densities

Many surveys of budworm outbreaks since 1950 have included samples of the populations of hibernating instar II larvae, feeding instar IV or V larvae, pupae, adults, eggs, or egg masses (table 14). Measurements of these metamorphic populations (fig. 8) formed part of biological evaluations made to (1) determine the need for immediate action to reduce budworm populations to endemic levels in certain areas and (2) predict the trend of outbreaks in terms of the expected natural increase or decrease in the insect's numbers and the probable degree of subsequent defoliation (*8, 9, U46*).

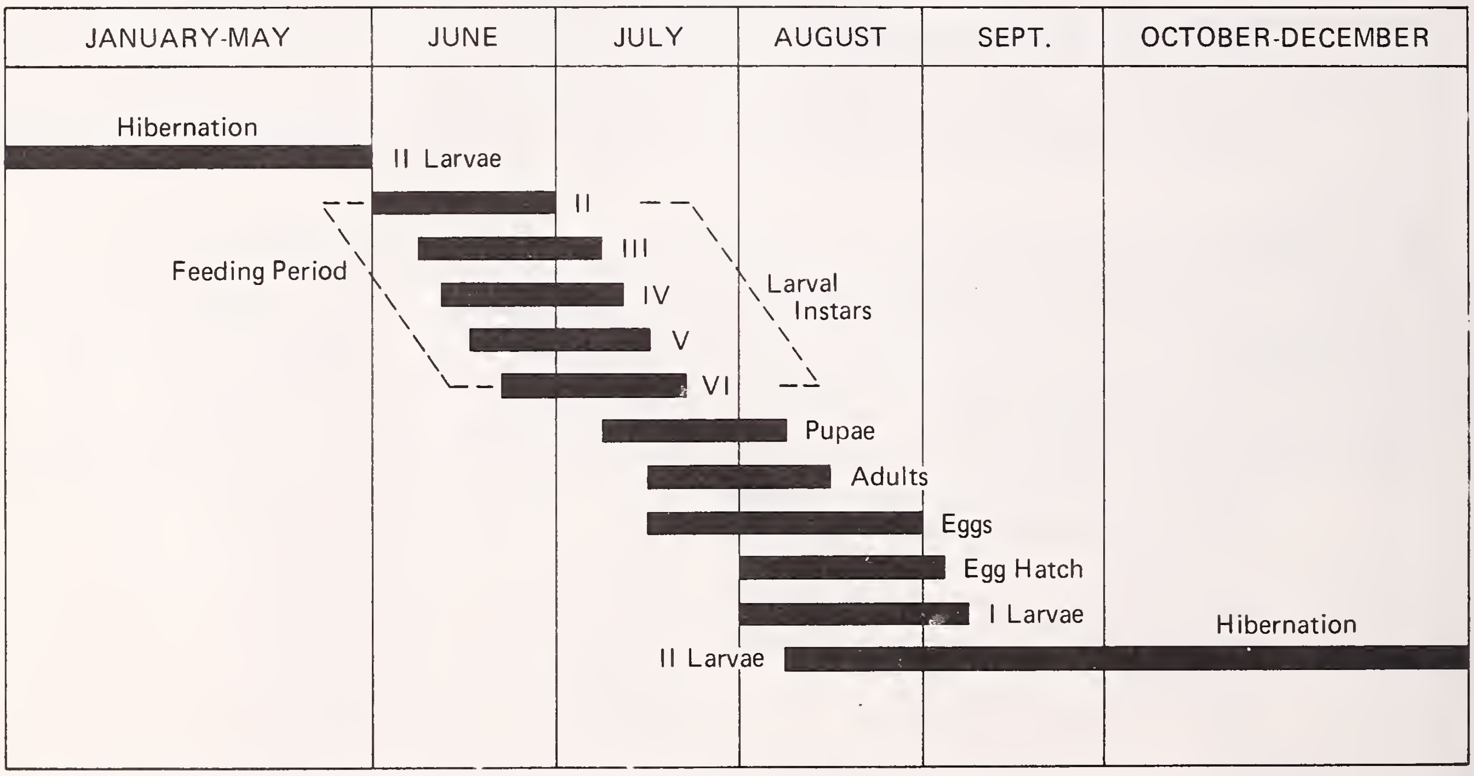


Figure 8.--Phenology of the western spruce budworm on Douglas-fir trees at 4,200 to 5,000 ft elevation in western Montana, 1963. (Data from Tom T. Terrell, associate entomologist, Northern Region, USDA Forest Service.)

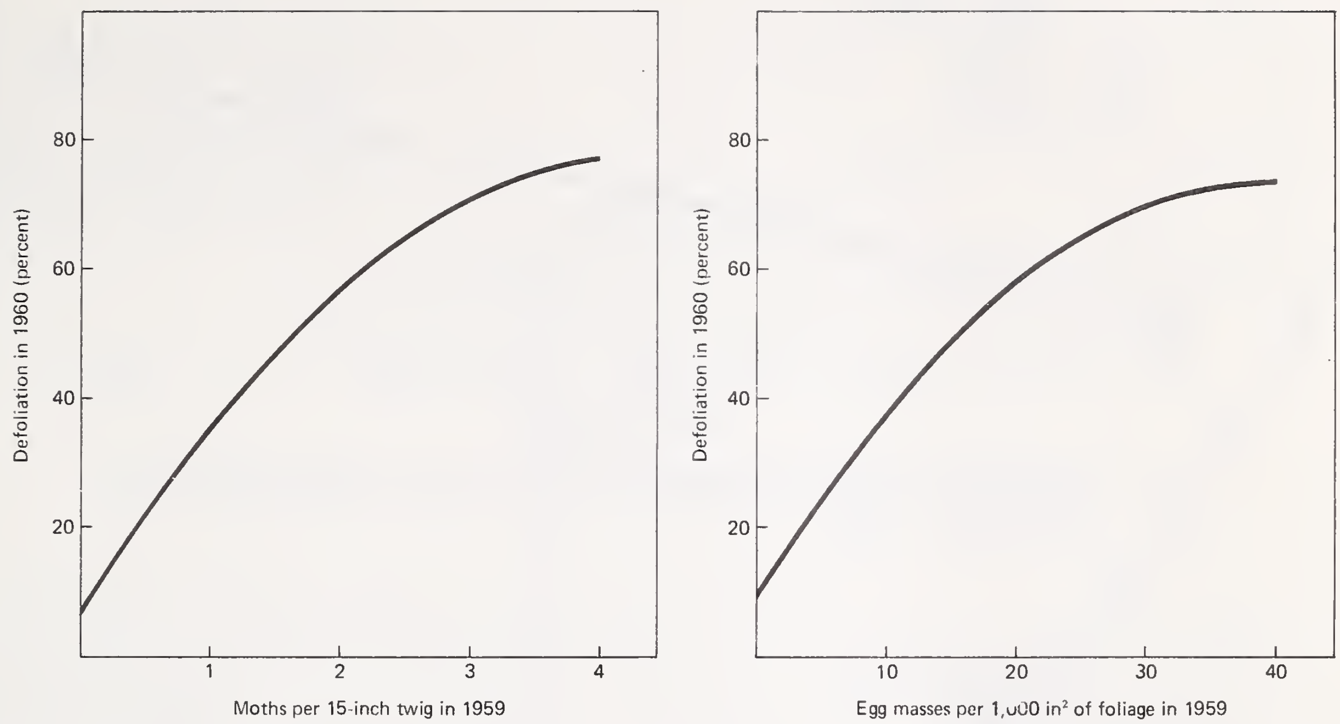
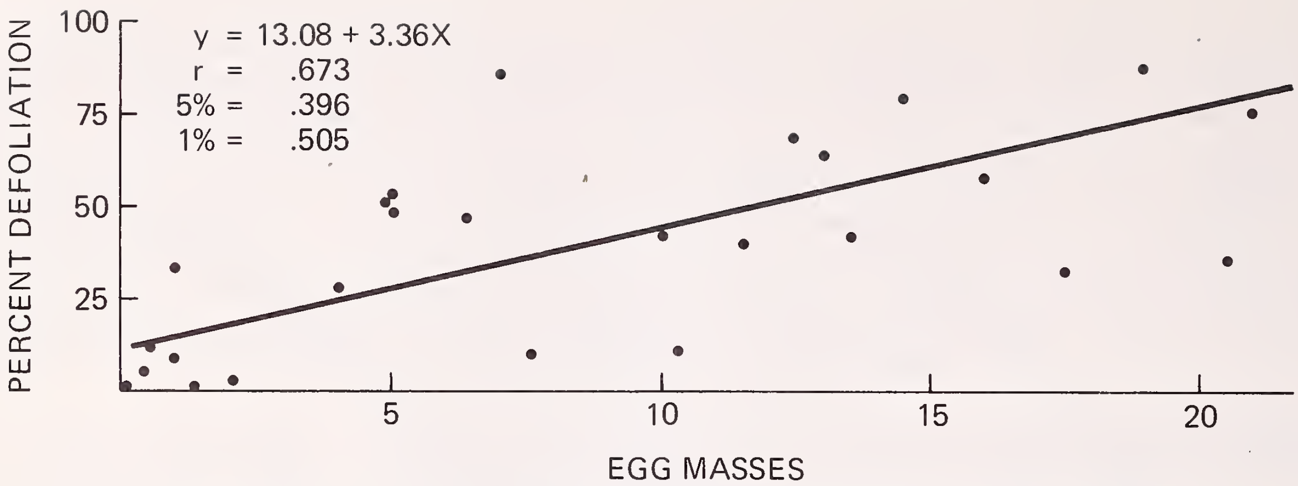


Figure 9.--Relationship between the average number of newly emerged moths and numbers of egg masses of western spruce budworm in 1959 and the average percentage of defoliation in 25 Douglas-fir stands in Montana in 1960. (From Terrell (U224))

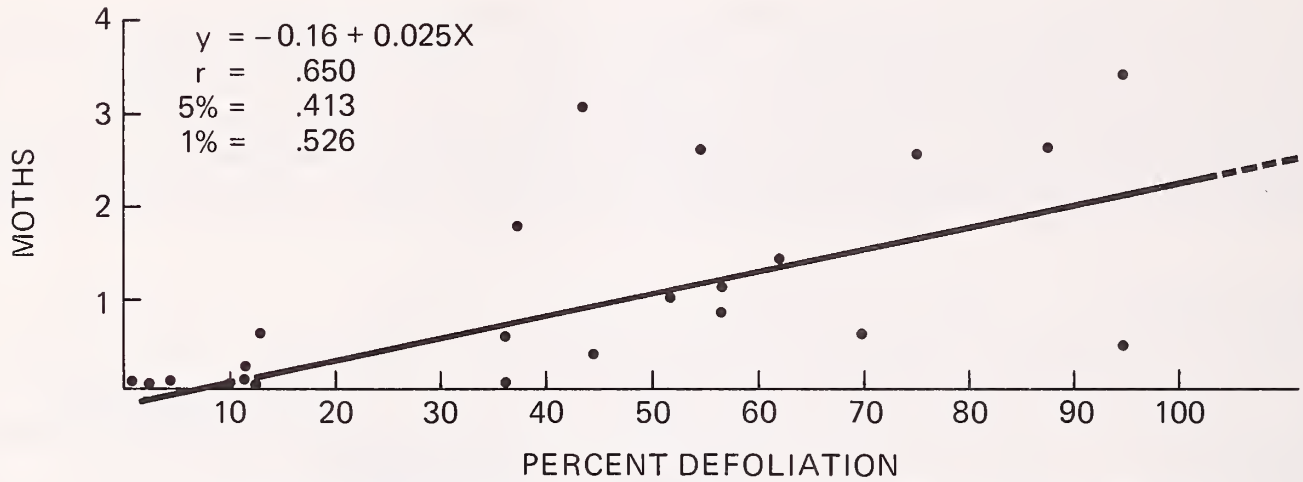
The first objective usually was easily achieved. Measurements taken during surveys either established the need for applied control action by confirming the presence of epidemic populations of the insect in specific localities, or they pointed to the futility of such action by revealing the absence of these populations in areas where they had been suspected. Measurements for this purpose are most effective if they are promptly applied to limited areas. These measurements were based on the premise that populations would change but little between the time they were measured and the beginning of control operations.

Under the same conditions, estimates of budworm populations adequately predicted trends of certain infestations and the probable amounts of defoliation to be expected during the budworm's next feeding period. Wherever the interval between population measurements and the following budworm feeding period was increased, the trends of infestations expressed by anticipated levels of population and defoliation were less accurate (table 15). During this lengthened interval there were more opportunities for changing biological and environmental factors to influence the size of subsequent measured populations.

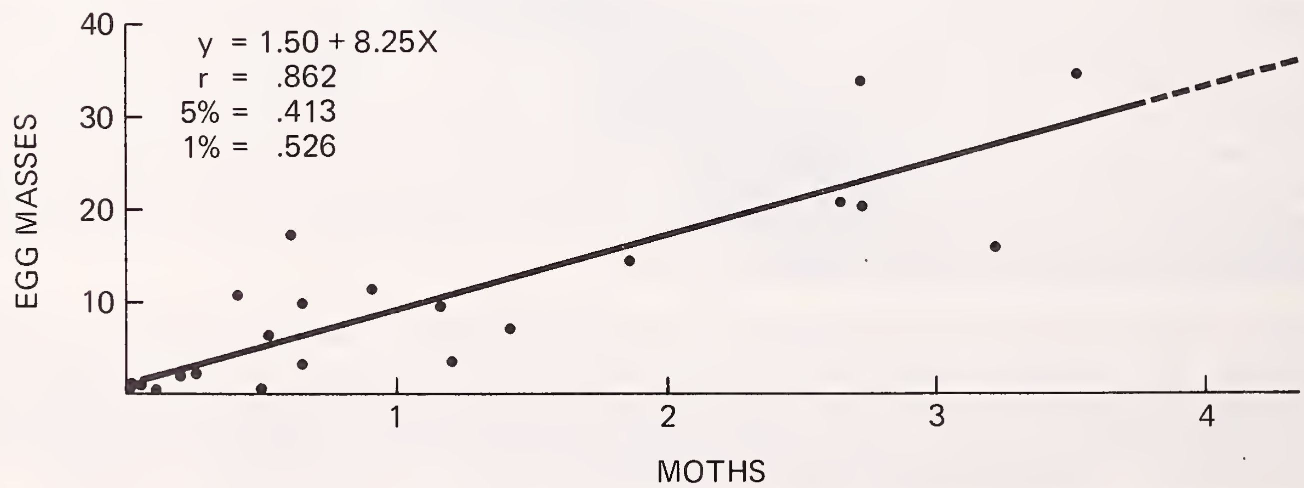
This interaction between biological and environmental factors usually regulates the density of a budworm population at any given time or place. It explains the wide difference in population densities over extensive areas in a given year (table 16). It also makes difficult the generalization of such particular budworm population correlations as those expressed in figures 9 and 10.



A. — Relationship of egg masses per 1,000 in ^{2} of foliage in 1958 to percent of defoliation in 1959



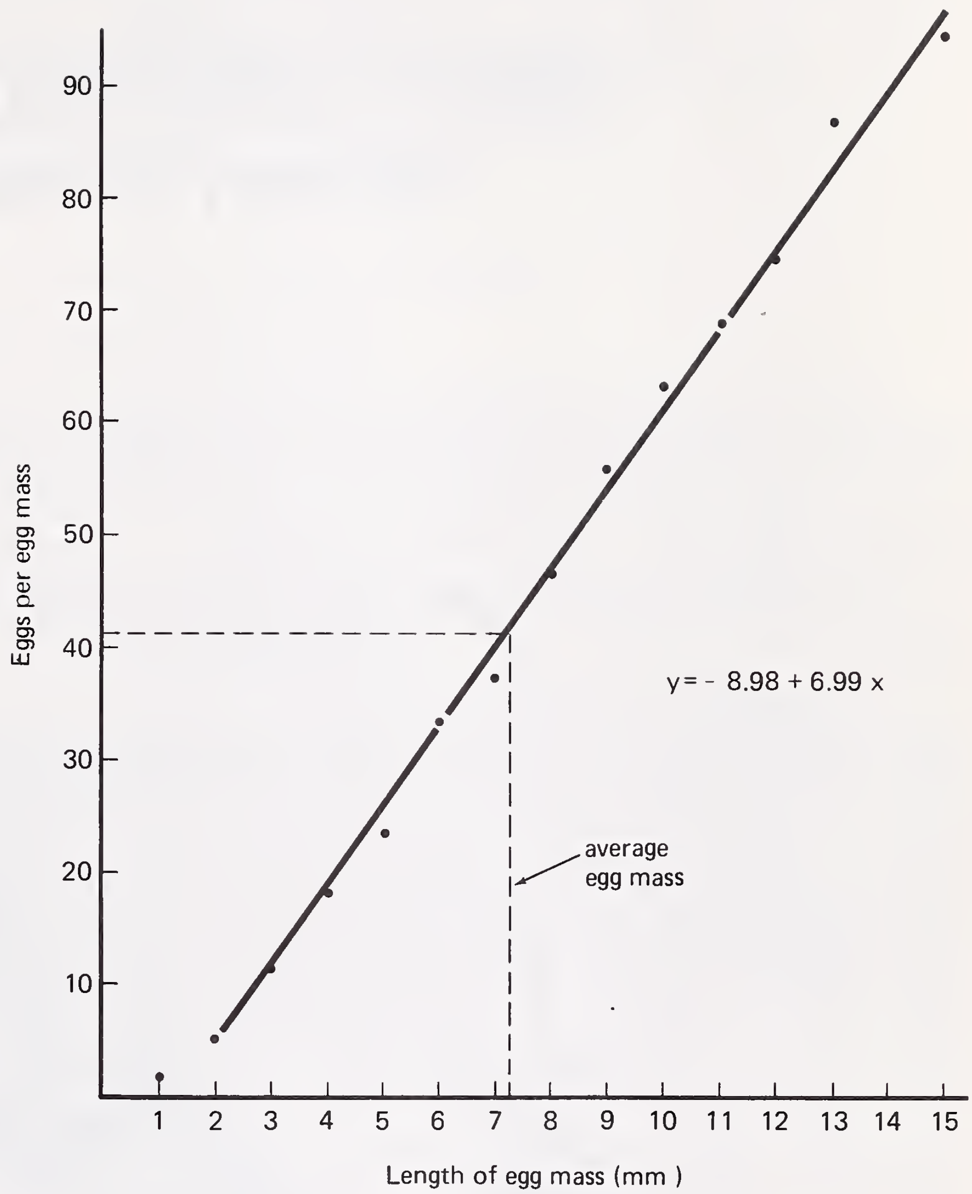
B. — Relationship of percent of defoliation to moths per 15-inch twig in 1959



C. — Relationship of moths per 15-inch twig to egg masses per 1,000 in ^{2} of foliage in 1959

Figure 10.--Relationships between numbers of egg masses, percentage of defoliation, and abundance of moths of the western spruce budworm in 25 Douglas-fir stands in Montana. (From Terrell and Fellin (U238))

Figure 11.--Relationship between length of egg masses of western spruce budworm deposited on Douglas-fir foliage in Montana in 1960 and the number of eggs per egg mass. (From Terrell (U224))



When sampling procedures are adequate, the abundance of current-season eggs appears to be more reliable than measurements of other metamorphic populations of the insect for predicting the trend of an infestation from year to year, and for forecasting the amount of defoliation expected the following year (*U224*). Recent biological evaluations of budworm outbreaks have used this measure of population almost exclusively. Egg masses can be readily collected and counted and the size of the masses can be quickly converted to numbers of eggs (fig. 11).

The destructive capability of each of the natural budworm control factors (described later in this paper) has been either measured or surmised from observations; but their epidemiologies, or occurrence patterns, are mostly unknown. Until this information is available, the appearance, probable severity, and subsidence of budworm outbreaks cannot be accurately forecast from weather or biological measurements made as part of outbreak evaluations.

EFFECTS OF OUTBREAKS ON HOST TREES

Defoliation resulting from consumption of part or all of the current season's needles by feeding instar II-VI larvae is the immediate and most obvious effect of infestation by epidemic populations of the western spruce budworm (fig. 12). It can be least damaging when it results from single-year outbreaks or from the first year of prolonged outbreaks. Physiological functions of the attacked trees can be maintained only by lessened photosynthetic activity of the remaining older needles. The physiology of infested trees may be more seriously impaired if the loss of current-season needles continues for 2 or more years. The foliage complement of trees may gradually diminish until crowns are completely defoliated.

Figure 12.--An example of 100-percent defoliation of current-season Douglas-fir foliage in the first year of an outbreak of western spruce budworm.

Whether defoliation resulting from budworm outbreaks is likely to be partial, and presumably recoverable, or complete, and doubtless irrecoverable, depends on (1) duration of the outbreak, (2) density of the budworm population, (3) relative susceptibility of individual host trees to larval feeding, and (4) stand composition.

The initial physiologic disturbance in infested trees is reduction in amounts of available carbohydrates. These food components required for tree life are chemical compounds synthesized in chlorophyll-containing needles by photosynthesis (*63*). When carbohydrate content is reduced, growth of vegetative and reproductive tissues and organs is reduced or aborted. If this debilitating action continues, the life and structure of affected trees deteriorate by the following process:

1. Stems produce less wood.

2. Fewer vegetative buds, flowers, and cones are produced.

3. Parts of the aerial and root structures die.

4. Abnormal budding develops that may deform both crowns and stems.

5. Root rots or bark beetles may subsequently infest weakened trees.

6. Whole trees may die.

Deterioration of completely defoliated host trees usually follows this recognizable syndrome that is often observed during budworm surveys:

1. The initial visible response of host trees is acceleration of adventitious vegetative budding; this produces numerous but stunted needles and in time is followed by suppression of budding.

2. The rate of annual radial and longitudinal increment declines.

3. Defoliated trees do not produce cones in years when cone production normally is high (*U265, U272*), even when the use of available carbohydrates for cone and seed development takes precedence over that for such vegetative parts as stem tips and cambium (*63*).

4. Top killing of tree crowns appears (fig. 13).

5. Rootlets die in the process of balancing the loss of photosynthetic surface caused by the defoliation (*63*).

6. Branches die as their foliage is destroyed.

7. Epicormic branches bearing juvenile needles (*16*) appear along the clear parts of the bole below the crowns, but sometimes they extend into the crown (fig. 14 and 15).

8. Tree may die from loss of all original foliage and the failure of epicormic-produced foliage to sustain physiologic functions.

Some species of host trees consistently suffer greater defoliation from budworm feeding than do other host species growing in the same forest community. In forests containing mixed stands of grand fir and Douglas-fir, white fir and Douglas-fir, or subalpine fir and Engelmann spruce, the first-named species often is the one more heavily defoliated. Douglas-fir in pure stands often is defoliated as heavily as *Abies* in mixed stands--sometimes more heavily. The frequency of budworm-caused mortality has been greatest in pure stands of Douglas-fir.

Figure 13.--Varied susceptibility of individual host trees to infestation by western spruce budworm. Exposure to several years of epidemic budworm populations left the Douglas-fir trees on the right almost completely defoliated. Neighboring Douglas-fir trees (left) exhibited only minimal tip killing similar to that often resulting from larval feeding during the first year of an outbreak.

Figure 14.--After losing most of its crown structure following several years of heavy defoliation by feeding budworm larvae, this Douglas-fir tree is surviving on aberrant foliage produced by epicormic branching and from restored normal foliage in the extreme top crown.

Figure 15.--Epicormic branching on mature Rocky Mountain Douglas-fir trees (center, left) stimulated by almost total defoliation and branch killing from infestation by successive populations of western spruce budworm. Survival of such trees is precarious until normal foliage complements are restored.

Seedlings, saplings, and pole-size trees growing under overstories of mature trees of the same budworm host species usually sustain greater defoliation and consequent mortality from the budworm long before their upper-canopy counterparts. This frequent happening is the basis for a popular belief that the budworm prefers young trees.

Young understory trees are defoliated, or die, sooner than older, larger infested trees in the forest for several reasons:

1. A larger proportion of the total foliage of young trees is current-season needles, which the feeding budworm larvae prefer; consequently, the complement of these needles is devoured or destroyed by feeding larvae very quickly. Young trees can be totally defoliated and killed in as short a period as the initial 2 years of an outbreak.

2. While fewer budworm eggs may be deposited in the understory trees, the population of feeding larvae may be extraordinarily dense because of developing primarily from larvae that have dropped from overstory trees either directly into the crowns of the understory trees or to the ground, from whence they can crawl into these crowns. Personal observations suggest that this transfer of larvae from overstory to understory trees may occur during any larval instar. On a unit of foliage basis, populations of budworm larvae feeding on understory trees at any given time may equal or exceed those on overstory trees that are supporting many times the amount of foliage.

3. Since small understory trees grow in shade and have less than a normal amount of foliage, their photosynthesis is limited and they cannot produce abundant carbohydrate reserve. Therefore, a reserve that is already largely suppressed can diminish or disappear quickly when photosynthesis is reduced further by defoliation.

Dendrochronographs from hundreds of increment cores and transverse bole sections collected from outbreak areas have revealed varied patterns of reduced radial bole increment from trees that have been partially defoliated or killed. Others are being studied to relate these declining growth rates to outbreak severity or to the occurrence and intensity of biotic or environmental factors that may have triggered them.[9]

Several considerations affect the amount and timing of reduced radial increment; they diminish the likelihood that defoliation results in any typical pattern of increment loss. These considerations also include the severity of defoliation, the number of seasons it continues, and the amount of reserve carbohydrates in the trees (*63*). Combinations of these factors, with other growth-inhibiting causes excluded, can create a myriad of patterns of growth loss. This theory appears to be substantiated by dendrochronological investigations of the western spruce budworm in British Columbia (*86*) and Oregon (*119, 120, 121*) and of the spruce budworm (*C. fumiferana*) in eastern North America (*5, 6, 23*).

After initial defoliation of current-season needles, the next visible indication that infested trees have become physiologically impaired is the dieback of the terminal and extreme uppermost lateral twigs. As in young trees, current-season needles comprise the major foliage complement of the upper crown extremities in older trees. Because most of them can be destroyed during the first year of an outbreak (fig. 13), experienced survey entomologists watch for this telltale sign of the budworm's abnormal abundance in a forest.

As the infestation continues into its second or third year, initial crown-tip killing may extend farther down the boles until a considerable portion of the upper crowns of infested trees is dead. This is the typical top killing that characterizes much of the visible host tree damage caused by budworm outbreaks.

Young coniferous trees overcome the loss of their upper bole terminals by replacing them with lateral branches that may develop into new vertical leaders. Mature trees are usually unable to replace top-killed portions of their boles. As defoliation voids the middle and lower branches of foliage, top killing may eventually encompass most of the crown portion of the boles. The dead stems, or "stag tops," may remain in place for years as an eyesore, as a likely site for decay, as an increasing cull factor, and as a hazard to woods workers.

Tree crowns approaching complete defoliation allow an increasing amount of light to reach heretofore shaded bole areas. This added light stimulates long-dormant epicormic buds along the boles; these buds may sprout if the outer bark is not too impenetrable (*16*). Epicormic branching that results from this sprouting produces a flush of juvenile foliage along the boles from points below to within the crown area (fig. 14 and 15). The chance of survival for trees in this stage of the budworm damage syndrome rests heavily on the permanence and photosynthetic capability of this epicormic foliage.

Epicormic-induced foliage that followed almost complete defoliation by the Douglas-fir tussock moth in northern Idaho in 1947 was unable to sustain mature grand fir trees for more than 1 year after the moth outbreak collapsed. In contrast, many Douglas-fir trees on xerophytic sites in central Montana have survived almost complete defoliation by the budworm, presumably because vital physiological functions of the trees were sustained by this type of foliage.

Sawlog-size Douglas-fir trees heavily defoliated by the budworm may become susceptible to lethal attacks by the Douglas-fir beetle, *Dendroctonus pseudotsugae* Hopkins (fig. 16); this virtually assures the killing of trees that might survive the budworm.

---

[9]Richard I. Washburn and William H. Klein. Personal communications.

Figure 16.--Stripped of most of its foliage by the western spruce budworm, this mature Douglas-fir tree became lethally infested by the Douglas-fir beetle, Dendroctonus pseudotsugae.

Outbreaks of the bark beetle in forests heavily damaged by the budworm have been reported occasionally from widely scattered localities since the 1930's. Several examples of such outbreaks are:

Administrative area	*Ranger District*	*Year*	*Reference*
Yellowstone N.P.	North	1924	(*U62*)
Yellowstone N.P.	North	1925	(*U19*)
Helena N.F.	Canyon Ferry	1949	(*U266*)
Helena N.F.	Townsend	1949	(*U266*)
Bitterroot N.F.	West Fork	1951	(*U257*)
Flathead N.F.	Big Prairie	1951	(*U114*)
Flathead N.F.	Spotted Bear	1951	(*U114*)
Gallatin N.F.	Bozeman	1958	(*U220*)
Gallatin N.F.	Bozeman	1966	(personal observation)

The death of trees, the final result of budworm infestation, has been abundant in some outbreak areas. Death of seedling, sapling, and pole-size host trees can usually be attributed to budworm-caused defoliation. Mature host trees may also succumb to this defoliation, but many survive; some may eventually die from subsequent attacks by bark beetles or other secondary insects.

EFFECTS OF OUTBREAKS ON HOST FORESTS

Reports of outbreaks of western spruce budworm during the past 50 years documented varied kinds and amounts of damage to the host tree element of involved forest ecosystems. Host forests occasionally survived outbreaks intact and comparatively unscathed. Others had residues of badly damaged trees, of dead trees, or both (fig. 17). Damage reported in most infested forests was estimated to have been somewhere between these extremes.

Figure 17.--This scene from Helena National Forest shows most of the common types of host tree damage caused by the western spruce budworm. Damage types represented: dead overstory tree (left), light tip killing (dominant tree, center), top killing (left of center), advanced defoliation (right of center), and extensive killing of understory trees (behind foreground trees).

We have reached this conclusion after studying subjective evaluations of the relative amounts of different types of tree damage or of dead trees made by many persons who investigated or reported the outbreaks. Their assessment of damage accrued during outbreaks, based on what was obvious and visible, was a valuable contribution to our knowledge of budworm epidemiology. We have left to forestry specialists the task of describing the longer term effects of the damage on the multiple resources of the infested forests.

Silviculturists have benefited from many cause-and-effect studies of biotic and climatic phenomena that influence tree growth and forest productivity. While few of these studies directly involved the budworm, results from some of them indicated that effects of certain phenomena were similar to those produced by the budworm. The effect of defoliation, for instance, is nearly always the same regardless of its cause. Because of this, silviculturists have long been able to foresee the nature, and often the magnitude, of temporary or more lasting effects of budworm outbreaks on the timber in host forests.

In the last two decades, specialists in the plant and animal sciences have adapted a growing amount of research-based information, or have directed more of their own research effort, to the forest environment. Statements about the effect of budworm outbreaks on all uses of host forests are beginning to appear frequently. Still, information exclusively on the effect of budworm outbreaks on the major uses and values of these forests is practically nonexistent.

By drawing on existing knowledge and on the considered judgment of specialists in forest use, we have compiled examples (table 17) of short- and long-term effects of budworm outbreaks on commonly recognized forest uses in the northern Rocky Mountain area.

The degree to which effects of budworm infestation listed in table 17 might appear in specific forests depends chiefly upon the intensity of feeding by one or more generations of budworm larvae. It depends also upon the combining of existing site and stand conditions with the appearance of certain biotic and climatic events:

1. The exposure, elevation, and general landform of the sites.

2. The physical, chemical, and water-holding properties of soils.

3. The species composition, density, and age class of trees in the stands.

4. The nature and abundance of ground vegetation.

5. The effect of other insect infestations or pathogenic infections to host and nonhost trees in the stands.

6. The effects of catastrophic fires or of weather preceding, during, or closely following the budworm outbreaks.

Over the years, many statements of the impact of budworm outbreaks on host forests have appeared. Some were made in reports of outbreaks to provide foresters and other land managers with some indication of the seriousness of the pest. Others were made to show need for costly budworm control programs. These early statements were based on conjecture, for it was not until the late 1950's that foresters attempted to ascertain specific impacts of some outbreaks.

A pioneering survey to determine the impact of budworm outbreaks was made during 1964 and 1965 in the Salmon and Challis National Forests by the Division of Timber Management, Intermountain Region, USDA Forest Service (*U195*). Established timber survey plots were used for measuring host tree radial increment, crown form damage, cone

production, regeneration, and outright mortality from outbreaks then in progress. The total damage of the outbreaks to commercial timber was a measurable objective, but the survey also attempted to evaluate subjectively the probable effect of tree damage on the functioning of watersheds, wildlife habitats, fisheries, and recreational areas.

Approximately 3,100 host trees at 66 sampling locations were closely examined. Most of them were within currently infested forests. Following are some types of damage measured in the survey, and potential effect on different forest resource values:

Commercial timber stands

1. Trees killed by the budworm were all less than 9 inches d.b.h. and averaged 19 per acre.

2. One-third of all trees tallied had some kind of crown form damage: dead tops, 16 percent; extreme top defoliation, 4 percent; or dead branches, 15 percent.

3. Marketable Christmas trees averaged 50 per acre; 68 percent of them had been rendered unfit for sale because of defoliation--an estimated loss of $34 per acre.

4. Despite a fair Douglas-fir cone crop in 1965, no cones were produced on trees more than 50 percent defoliated.

5. No Douglas-fir reproduction 6 inches or less in height was found at 30 sampling locations where site conditions were favorable but where defoliation of overstory trees had continued for 2 or more years; some reproduction was recorded at 28 other favorable sites, where defoliation was light.

Watersheds

Measured tree damage indicated no apparent effect on water production or patterns of runoff.

Fire hazard

Faster drying of fuels under defoliated tree canopies, probable increase in number and severity of fires from lightning-struck snags, and accumulated flash-type fuels (dead needles, twigs, and branches) were regarded as hazardous at some sampling locations but not at others.

Forage production

Abundance of forage plants was increased at 5 of 63 sampling locations where this factor was measured; trees at each of the 5 locations had been infested by the budworm for at least 5 successive years.

Wildlife

Severe tree defoliation at 2 of 63 sampling locations resulted in undesirable loss of cover for shading or concealment of animals. At 7 locations, desirable thinning of tree thickets enabled passage of animals and establishment of forage or browse plants.

Recreation areas

Recreation values were judged to have been reduced by budworm damage at 11 sampling locations. Factors assessed included loss of tree cover in picnic and campground areas and undesirable esthetic ratings for heavily defoliated forests within view of much-used sites and thoroughfares.

Studies in 1964-1968 of the budworm's larval feeding behavior revealed new forms of the budworm's impact on some host forests. For instance, a study in northwestern Montana disclosed widespread severing of the stems of new terminal and lateral shoots on young western larch trees (*42, 44, 83*). The feeding of several consecutive generations of budworm larvae in several naturally reproduced stands of seedling and sapling larch trees drastically increased the incidence of stem crook and multiple leaders among individual trees. The regenerative capability of the infested stands clearly had been jeopardized by the resultant reduction in juvenile height growth and increase in undesirable crown forms in a large proportion of the trees. Ironically, cone damage was heaviest in larch stands that suffered almost no defoliation. Data from the study were insufficient to determine how much of the larval stage was spent in the larch cones, or to what extent this form of damage prevails in budworm-infested forests of western larch (*45*).

A similar study revealed that the budworm had fed upon and destroyed more cones and seeds of Douglas-fir than any of 15 other cone and seed insects collected and reared from 13 sampling areas in western Montana and Yellowstone National Park during 1967, 1968, and 1969. Budworms were in cones from every area in each of the study years. Where defoliation was aerially visible, from 56 to 68 percent of all cones examined had been damaged by budworm feeding. In areas where budworm defoliation was not aerially detectable, cones damaged by this insect averaged from 22 to 25 percent of the total number sampled (*29, U53, U54, U55*).

In 1965 Fauss and Pierce (*40*) studied the relationship between site quality, crown closure, and the percentage of Douglas-fir and the amount of defoliation of this species from a 5-year-old infestation of the budworm in the Blackfoot River drainage of western Montana. They concluded that:

1. Defoliation was significantly less on moist bottomland sites than on drier hillsides.

2. Open stands were defoliated considerably less than stands having dense canopies.

3. Stands containing a low percentage of Douglas-fir were defoliated less than stands having a high percentage of Douglas-fir.

4. Buildup of budworm populations might be prevented silviculturally by reducing Douglas-fir stocking to low levels or by changing the stand composition to favor nonhost tree species; both these practices presumably are not needed on good quality sites and are economically unfeasible on poorer sites.

A survey conducted jointly by the Forest Insect and Disease Branch, Northern Region, USDA Forest Service, Missoula, Mont., and the Clearwater National Forest, Orofino, Idaho, in 1971 on 500 acres of the Yoosa Creek drainage of the Clearwater National Forest was designed to determine how much timber had been infested, how much top killing had occurred, and how much tree growth might have been lost from a budworm outbreak that began in 1966. The following volumes of budworm-infested timber were reported from the study area (*U98*):

Species	*Total volume/acre (Fbm)*	*Infested volume/acre (Fbm)*	*Percent*
Grand fir	9,403	9,317	99.1
Engelmann spruce	2,252	2,181	96.8
Douglas-fir	1,255	1,239	98.7
Subalpine fir	772	772	100.0
Western redcedar	405	0	0
Western larch	213	0	0
Western white pine	211	0	0

Top-killed grand fir trees were 4 percent of all trees of this species tallied, but were only 1 percent of the total volume; this indicated that the smaller grand fir trees were more readily top killed.

Radial increment for the 5-year infestation period averaged 22 percent less than for the previous 5 years in 12 trees representing the four major host species.

Two other surveys of the impact of budworm outbreaks were begun in 1971. Preliminary data were collected throughout the Intermountain Region to measure growth loss of host trees, crown form damage, and mortality, as well as other resource values that may have been affected by host tree damage. The study's aim was to determine how much resource damage can be tolerated by the several forest uses before expenditures for applied control are justified (*80*).

Pest control entomologists and timber management specialists in the Northern Region are measuring the impact of an outbreak of western spruce budworm that began in 1964 in the Nezperce National Forest. They are inventorying top-killed and budworm-killed trees from aerial photographs and from ground plots to ascertain the extent of permanent damage to the infested stands. From this inventory they can estimate resource losses on a compartment basis using multistage probability sampling. Stage I, a sketch map from an aerial survey, showed 138,000 acres of aerially visible top killing and tree mortality on the forest resulting from the current budworm infestation.[10]

Study of the impact of the western spruce budworm on host forests has priority in a proposed comprehensive research and development program that might be conducted jointly by the Forest Service, cooperating State agencies, and universities. Through systems analysis and computer experimentation, the program is designed to provide basic knowledge and understanding needed to develop an integrated system of techniques for managing population densities of the budworm.[11] Measurements of budworm populations will be correlated with host conditions to predict the intensity and extent of host damage and its relation to the forest resource.

By this coordinated approach, participating scientists and forest managers will try to assess the following impacts from budworm outbreaks:

1. Effects of budworm populations on growth and mortality of individual host tree species.

2. Frequency, duration, distribution, and severity of budworm outbreaks in the West since 1920, including geographic, historic, and climatic relationships.

3. Susceptibility and vulnerability of host trees and stands in various ecological environments and under varied management regimes.

4. Effect of budworm feeding on production of cones and seeds.

5. Susceptibility of host trees to other destructive agents after defoliation by the budworm.

---

[10]Jerald E. Dewey, Entomologist, USDA Forest Service, Northern Region, Missoula, Mont. Personal communication.

[11]Boyd E. Wickman, Research Project Leader and Program Coordinator, USDA Forest Service, Forestry Sciences Laboratory, Corvallis, Oreg. Personal communication, Nov. 1972.

Figure 18.--This stand of Douglas-fir saplings and small poles in Deerlodge National Forest has undergone several years of heavy defoliation by the spruce budworm. Many trees have died; residual trees have sustained serious form damage.

Except in the matter of infested acreage already discussed, we cannot now quantify the massive damage tht the budworm has caused during 50 years of widespread outbreaks in the Rocky Mountain area. To those who investigated, surveyed, or reported the many outbreaks, the record of damage has been unmistakably visible and impressive:

1. The light, moderate, or heavy defoliation of millions of seedling, sapling, pole- or sawlog-size trees which, silviculturists know, represents enormous volumes of wood that were never produced.

2. The top killing and other crown or stem deformation that developed in millions of these trees as a secondary effect of defoliation; damage that contributed to staggering amounts of potential degrade and cull in poles and sawn products.

3. The killing of entire understory forests over broad areas and the general depletion of growing stock on many thousands of acres resulting from complete defoliation and consequent killing of millions of seedling, sapling, and pole-size trees (fig. 18).

4. The decimation of harvestable sawlog tree overstory stands on thousands of acres of host forests with resulting economic and esthetic losses (fig. 19); losses that added immensely to the costs of planning and managing forced salvage of dying and dead timber (fig. 20), increased fire protection, and the cleanup of recreational areas (fig. 21), roads, and trails.

Figure 19.--Defoliation from successive epidemic populations of western spruce budworm between 1948 and 1953 caused this catastrophic tree killing on a 500-acre south-facing Douglas-fir stand in White's Gulch, Helena National Forest.

Figure 20.--Frail remnants of a fully stocked Douglas-fir pole stand. Almost completely defoliated by an outbreak of western spruce budworm, these trees survived only because of extensive epicormic branching. Most trees killed during this infestation were cut and salvaged. Brackett Creek Drainage, Gallatin National Forest.

Figure 21.--Extensive tree killing and deformity of surviving trees following infestation by western spruce budworm in a recreation area in Gallatin National Forest between 1945 and 1950.

5. The further killing of heavily defoliated pole and sawlog trees by infestations of bark beetles--particularly by the Douglas-fir beetle in Douglas-fir trees--in the years immediately following the termination of some outbreaks.

6. The expenditure of nearly $8 million in operating costs for aerially spraying 6.3 million acres of host forests to control the more virulent budworm outbreaks; usually accompanied by equal or greater matching costs in contributed planning, supervision, or the conducting of concomitant ecological impact studies.

7. The indeterminable amount of time and expense in revising management priorities and planning in forests drastically altered by accumulated damage to host trees; planning that must acknowledge the likelihood of further damage from the budworm until such time as developing technologies for regulating budworm populations become feasible.

NATURAL CONTROL AGENTS

Abundant experimental evidence has established that population densities of most insects are rigidly controlled by complex interactions of certain measurable biotic and environmental factors (*49*). Populations of the budworm undoubtedly respond similarly to the changing complex of these factors. Densities of budworm populations fluctuate from year to year and from place to place in response to (1) changes in weather phenomena, (2) abundance of insect and other animal parasites and predators, (3) levels of insect pathogens, (4) sex ratios of the budworm, (5) fecundity rates of adult female budworms, (6) viability of budworm eggs, and (7) the quantity and quality of available food.

While the effect of some of these factors on density of budworm population is fairly well understood (*76*), less is known about the net effect of combinations of factors that may increase or decrease the numbers of budworms. Least known are the effects of these composite natural control agents in regulating budworm populations and the consequent severity of outbreaks of the insect. Except in a few isolated outbreaks where dramatic changes in the size of budworm populations occurred, or did not occur when they were anticipated, the precise influence of individual or collective causative factors has not been determined as part of biological evaluations.

Weather records, for instance, have usually been examined closely only when some meteorological abnormality was suspected of causing a readily observed change in the abundance of the budworm in an area, as in the following events:

1. Lightning-caused conflagrations in the Clearwater and Nezperce National Forests in the 1930's that destroyed or damaged extensive host forests and their infesting budworm populations, and which denied food over wide areas to succeeding populations that might have survived in the burned areas, or migrated thereto (*U253*).

2. The suspected killing of hibernating instar II budworm by unusually cold temperatures during the winters of 1923-24 and 1924-25 in the Gallatin National Forest (*U255*), in contrast to the demonstrated survival of similar larvae in budworm-infested forests of Douglas-fir in the Blackfoot River drainage in western Montana, where temperatures during November 1959 reached lows of -45°F (-42.5°C) and -53°F (-47°C) (*U222*).

3. Unseasonably low air temperatures (18°F to 22°F (-12°C to -14.5°C)) in September 1965 in the Salmon National Forest which reduced egg hatching and presumably killed instar I and II budworm in high elevation host forests (*59*).

4. An unseasonably warm May followed by subfreezing air temperatures in the Salmon National Forest both early and late in June 1966, which killed a high percentage of the 1966 Douglas-fir foliage growth and the infesting instar III and IV budworm in it (*59*). This freeze undoubtedly had an indirect effect by destroying food that would have fed many surviving larvae. The mortality of budworms caused by this and the preceding autumn freezing weather justified cancellation of an aerial spraying program planned for July 1966 to control infestations in 120,000 acres of Douglas-fir forests.

5. Unseasonal air temperatures, as low as 21°F (-6°C), were recorded in the Clearwater and Blackfoot River drainages in western Montana in mid-June 1969, a period when budworm larvae were feeding on new foliage of host trees. Data from several ecological studies of budworm in progress in the areas provided evidence that populations were reduced by more than 90 percent on infested Douglas-fir, western larch, and ponderosa pine trees, and that budworm damage to young larch trees was reduced 54 to 71 percent from the previous year (*43*).

6. High surface winds associated with thunderstorm activity over the Helena National Forest on the afternoon of August 2, 1951, are believed to have concentrated flying budworm moths in infested Douglas-fir forests south and west of the city of Helena and to have positioned them to enable a strong phototropic response to carry them in a mass invasion of the urban center of the city on the windless evening of August 3.[12] [13] The junior author personally determined that a significant percentage of the moths in that spectacular flight were gravid females with partial or entire egg complements. In effect, the flight translocated a massive population of egg-bearing adult budworms from infested host forests to quick death in a sterile urban environment.

7. Other high velocity surface winds, common in the Rocky Mountains from high-low pressure gradients or from lee side turbulence caused by general westerly winds cresting sharp summits and low passes of north-south mountain ranges, frequent during the flight period of the adult budworms in late July and August.[14] These winds disperse budworm populations over wide areas along the eastern slopes of the Rockies.

8. "Red belt" phenomenon, particularly prevalent in Montana, causing winter drying--the desiccation and subsequent killing of the needles of coniferous trees exposed to short periods of warm temperatures in midwinter. Vegetative buds may be killed, but often they survive. When they do, the surviving host trees have proved to be poor sources of food for the budworm in the years immediately following the phenomenon. Budworm populations drastically diminished over wide areas of the Helena and Gallatin National Forests from "red belts" that developed during the winter of 1942-43 (*U265, U266*).

---

[12] Raymond Granger, Radar Meteorologist, U.S. Department of Commerce, National Weather Service, Missoula, Mont. Personal communication; interpretation of weather records.

[13] News reports of the mass moth flight into the city of Helena, Montana, by the (Helena) Independent Record, August 4 and 17, 1951, described the invasion:

> The...(budworms) covered neon signs, downtown store windows, street lights and anything else that shone. Persons leaving the carnival grounds... appeared to have swarms of bees hovering around their heads...One large Ferris wheel...was almost obliterated....Persons driving into Helena from higher elevations could observe a haze over the business district and when they came closer they could see it was the insect invasion....Siebrand Bros. carnival, boasting "the world's largest neon midway," had to shut down and city streets swarmed with the insects which blackened the downtown district's neon signs.

[14] Robert G. Baughman, Research Meteorologist, Intermountain Forest and Range Experiment Station, Missoula, Mont. Personal communication.

Dodge (*U56*) reared and identified insect parasites from budworm populations at five widely scattered locations in Montana from 1956 to 1959. He studied the singular or cumulative effect of one or several parasites in reducing populations of the budworm at these sites. The most numerous and effective parasites of the budworm in these forests then could be divided into four groups, depending upon the metamorphic stage of the budworm that was attacked (table 18):

Some data about the general abundance of the parasites and the interpretation made of their meaning by the Montana study are given here.

1. The greatest parasitism measured was that of hibernating instar II budworm by *Glypta fumiferanae* (Viereck) (Hymenoptera, Ichnuemonidae) and *Apanteles fumiferanae* Viereck (Hymenoptera, Braconidae). From 6 to 48 percent of this budworm stage was parasitized by the combined attacks of these two hymenoptera; *Glypta* predominated.

2. Decline of populations of *Glypta* and *Apanteles* during the study was attributed to mortality from secondary insect parasites.

3. Parasitism of budworm eggs by *Trichogramma minutum* Riley (Hymenoptera, Trichogrammatidae) on two of five plots in 1957 and 1959 varied from almost 9 to 22 percent; on the remaining plots in those years, it averaged only 0.4 percent. Apparently this parasite was not important as a budworm control agent during the study.

4. Parasitism of budworm pupae by *Phaeogenes hariolus* (Cresson) (Hymenoptera, Ichneumonidae) ranged from 0 to 23 percent.

5. Tachinid parasites proved to be unimportant, possibly because a second yearly generation of these flies requires an alternate host, which may have been sparse in the study areas.

6. Aggregate parasitism by the four groups of budworm parasites ranged from 22 to 51 percent.

The parasitoids identified by the Montana study had performed similarly against the western spruce budworm in British Columbia (*117*), Oregon (*17*), and Colorado (*34*).

There are no reports of outbreaks of this budworm having been controlled by entomophagous parasites in either the Northern or the Intermountain Region. One instance of such biological control was documented from the Pike National Forest in Colorado in 1963. There a relatively unimportant parasitic wasp, *Bracon politiventris* Cushman (Hymenoptera, Braconidae), along with other probable parasitoids, was credited by McKnight (*75*) with the sudden collapse of a budworm infestation destined for imminent treatment with aerially applied insecticides.[15]

Predation of the western spruce budworm by birds has been observed and reported several times, but the amount of mortality that developed was never determined.

In 1931, the supervisor of the Nezperce National Forest reported that "grosbeaks, flycatchers, and other small birds increased very materially and seemed to have been instrumental in checking the spruce budworm" (*U257*). In 1942, from 300 to 400 crows were observed feeding on budworm moths in Douglas-fir forests along Battle Ridge in the Gallatin National Forest (*U265*). Red squirrels, golden-mantled ground squirrels, and chipmunks have been observed preying on budworm larvae in Douglas-fir foliage in western Montana (*81*).

---

[15]R. H. Hamre. The case of the dying budworms. Empire Magazine of The Denver Post, p. 37 and 39, Dec. 1, 1963.

Neither Region has reported significant reductions in budworm populations resulting from insect pathogens.

Starvation is a common, but as yet unevaluated, agent for natural control of the budworm. In many prolonged severe outbreaks, feeding has been so intensive that successive generations of the insect have had progressively less food. In other outbreaks, epidemic populations of the budworm have competed unsuccessfully for food that was being, or had been, consumed by other foliage-feeding insects or had been destroyed by foliage-infecting fungi.

The spruce coneworm, *Dioryctria reniculella* (Grote) (Lepidoptera, Phycitidae), another defoliator, often feeds on the same new needle growth of Douglas-fir trees in Montana that the budworm is feeding on. We have observed and measured populations of the coneworm on the Beaverhead National Forest that exceeded in number those of the budworm that were being treated with DDT for control.

Other defoliating insects that occasionally compete with the budworm for food are the black-headed budworm, *Acleris variana* Fernald (Lepidoptera, Tortricidae), on Douglas fir, grand fir, Engelmann spruce, and western hemlock; the Douglas-fir tussock moth, *Hemerocampa pseudotsugata* McDonnough (Lepidoptera, Lymantriidae), on Douglas-fir, grand fir, subalpine fir, white fir, and Engelmann spruce; the larch bud moth, *Zeiraphera griseana* (Hübner) (Lepidoptera, Olethreutidae), on western larch, Douglas-fir, and Engelmann spruce; and the larch casebearer, *Coleophora laricella* (Hübner) (Lepidoptera, Coleophoridae), on western larch.

Outbreaks of the spruce spider mite, *Oligonychus ununguis* (Jacobi) (Acarina: Tetranychidae), sometimes run concurrently with those of the budworm in Douglas-fir forests; both the mite and the budworm destroy food needed by the other.

Infectious outbreaks of *Rhabdocline pseudotsugae* Sydow on Douglas-fir and *Hypodermella laricis* Tubeuf on western larch, two needlecast fungi (Ascomycetes), periodically damage or destroy foliage needed as food by the budworm.

CHEMICAL CONTROL OF BUDWORM OUTBREAKS

One of the first attempts to suppress an epidemic population of the western spruce budworm also was the first use of a chemical insecticide to control this pest. This pioneer effort continued from 1929 through 1932 to control a budworm outbreak in Cody Canyon (Wapiti Valley), Shoshone National Forest, Wyoming.[16] The program was unique in several other respects: (1) its experimental use in 1929 of a lead arsenate-fish oil-water formulation as a budworm larvicide (*U66, U211*); (2) its experimental use of the same toxicant to inhibit oviposition (*U73*); (3) its use of white petroleum (Volck) oil as an experimental ovicide (*U70*); (4) its use of high pressure hoses and nozzles to spray the toxicant into tree crowns from the ground (fig. 22) (*U66, U211, U70*); and (5) its objective--to preserve the life and foliage of the host trees as a means of maintaining the Canyon's outstanding scenic qualities (*U66*).

The infestation, first reported in July 1922, was only partially controlled by the chemical because natural control agents began to take effect about 1930 to bring about its termination in 1932 (*U73, U74*).

Not until 1952 was a chemical insecticide used to control an outbreak of the budworm in this northern Rocky Mountain country. In that year, the authors were assigned the task of designing and supervising the aerial application of the chlorinated hydrocarbon insecticide, DDT, to 12,000 acres of budworm-infested Douglas-fir forests in the Sula Ranger District of Bitterroot National Forest (fig. 23) (*U106, U113*). This initial undertaking was essentially a trial of the effectiveness of the insecticide, of aerial dispersal techniques, and of entomological and administrative procedures previously developed in New York, Idaho, and Oregon (*35, U57, U95*).

Since then, the Forest Service has used aerially applied chemical insecticides in 25 experimental and 50 operational programs to control epidemic populations of the budworm on 6,338,600 acres of host forests in 15 National Forests and in lands administered by other Federal agencies within the northern Rocky Mountain area (table 19).

---

[16]The Shoshone National Forest is part of the Rocky Mountain Region (Region 2 of the USDA Forest Service, but was then under the entomological jurisdiction of the Forest Insect Laboratory of the Bureau of Entomology (later called bureau of Entomology and Plant Quarantine) at Coeur d'Alene, Idaho.

Figure 22.--The first known use of a chemical insecticide to control an outbreak of western spruce budworm was this spraying of lead arsenate-fish oil emulsion from high pressure hoses in Cody Canyon, Shoshone National Forest, Wyoming, in July from 1929 through 1932. Under guidance by entomologists from the Forest Insect Laboratory of the Bureau of Entomology at Coeur d'Alene, Idaho, this spray program was undertaken to prevent defoliation and killing of Douglas-fir trees in a heavily used recreation area.

Figure 23.--The first aerial application of chemical insectide for control of western spruce budworm in the Northern and Intermountain Regions was this dispersal of DDT over budworm-infested Douglas-fir trees in the east fork of the Bitterroot River, Bitterroot National Forest, July 1952.

Operational Control Programs

The objective of operational control programs was to reduce populations of the budworm to endemic levels in specific host forests where there appeared to be immediate danger of heavy mortality of trees. This was attempted by spraying the infested forests with prescribed dosages of chemical insecticides from low-flying aircraft. The programs followed biological guidelines that described techniques and procedures required to achieve acceptable reductions in the budworm populations to be treated (*U100, U116, U178, U215*).

Administrative guidelines were also prepared to assure effective compliance with fiscal and procurement requirements; assignment, training, and supervision of personnel; spraying procedures; and safety precautions, which were part of every program (*U273, U274, U275*). These guidelines were usually prepared by staffs of the two Forest Service Regional Offices in Missoula and Ogden, or by those of individual National Forests with the assistance of the Regional staffs.

After many operational control programs were completed, project personnel prepared detailed reports that described the biological effectiveness of the work (*U25, U48, U113*) or the operational accomplishments (*U17, U288*).

Preparation of technical specifications for aerially dispersing chemical insecticides to control the budworm depended heavily between 1952 and 1957 on reports of results of experiments in widely scattered sections of the country and from eastern Canada, some relating to the spruce budworm (*C. fumiferana*):

1. Airplane types and spraying apparatus (*35, U1, U2, U57, U95, U105*).

2. Effective widths of spray swaths (*35, U2, U57, U95, U105*).

3. Height of spraying above forest canopies (*20, 35, U1, U2, U34, U36, U57*).

4. DDT formulations and dosage rates (*26, U1, U57*).

5. Spray droplet size (*26, U1, U105*).

6. Assessment of spray deposits (*25, 67, 68, 69, 70, 95, U1, U2, U95, U105*).

7. Meteorological limitations (*U1, U2, U57, U95*).

The decision whether to proceed with spraying programs for budworm control usually depended upon biological and economic justification by informed entomologists and forestry resource managers. The need for controlling specific infestations was most often determined from these evaluations:

Biological Justification

1. Verifying the presence of epidemic populations of budworm.

2. Determining the probable trend of these populations after evaluating the effectiveness of natural population control agents that were present.

3. Ascertaining that epidemic populations of the budworm could be reduced to acceptable endemic levels for 1 or more years by proper application of a selected insecticide that had been registered for such use by appropriate Federal and State authorities. This determination implied that the recommended insecticide was highly toxic to the budworm in approved dosage, relatively nontoxic, or acceptably less so,

to nontarget terrestrial and aquatic insects, other animals, and vegetation, or to persons handling the compound or inhabiting the immediate environs of the proposed treatment area. Also, that practical methods were available for dispersing the insecticidal material over the forest at the recommended dosage.

Economic Justification

1. Evaluating the cumulate and predicted damage to the host trees and forests.

2. Determining the point at which this damage to the inherent uses and resources of the infested forests becomes intolerable.

3. Weighing the cost of spraying against the monetary or social values of the resource to be saved.

4. Assuring that funds, manpower, equipment, and time were available to conduct the proposed programs properly.

Operational budworm control programs between 1953 and 1958 were designed and performed under the concept of "entomological control units." A generally accepted hypothesis among specialists in insect control, this implied that satisfactory reduction of epidemic insect populations could best be accomplished by treating entire infestations or infested host areas. Boundaries of these control units were either the demarcation between epidemic and endemic populations of the pest insect or the perimeter of the host type. Assuming that control treatment could restore endemic populations, the concept supposedly prevented or delayed reinfestation of the treated area for a reasonable time from untreated populations of the insect that might be present outside the unit. It appeared to be workable in the two Forest Service Regions because mountainous terrain created mosaics of host and nonhost forests and of forested and nonforested lands.

Unfortunately, the theory did not work well here. In most outbreaks, there were not enough control dollars to treat all of the extensive acreage of infested host forests that confronted operation planners. Too many control dollars were necessarily deployed to areas of light infestation where budworm populations and host tree damage were minimal, while other areas, which had exceedingly dense populations or heavy host damage, went untreated.

Beginning in 1958, more effective use of limited control funds was achieved by adopting a system of "partial unit control" (*U51, U97*). Under it, aerial spraying to control budworm populations was directed to those areas where most of the host trees were in imminent danger of dying if exposed to further infestation. Control programs that used this system have undoubtedly prevented the killing of thousands of host trees that might not have been saved under the whole unit method of treatment.

Techniques of aerial spraying for forest insect control were originally designed to use small single-engine airplanes. They were relatively safe for the low-altitude flying needed to deposit spray materials on specific targets at the proper dosage. When well powered, these planes were maneuverable enough for similar performance over mountainous terrain.[17] However, the limited capacities of their spray tanks and slow airspeeds were disadvantageous at times. Their frequent return to airstrips for spray refills was both nonproductive and costly. Extensive operational control projects using large numbers of these small aircraft were often saddled with monumental problems of traffic control at airstrips or established airports.

---

[17]These same small-plane performance standards have been achieved since 1947 in the two Regions by Ford tri-motor and C-47 twin-engine airplanes when flown by competent mountain pilots.

Commencing about 1955, the two Regions employed larger, faster, single- and multi-engine airplanes (TBM, B-17, PBY, etc.) to increase spraying production without proportionately increasing spraying costs. Spraying production drastically improved, but not without some compromise in the biological effectiveness of some control programs.

Being less maneuverable, the larger, faster planes necessarily maintained higher average spraying heights over rough terrain. This increased the chances of spray drifting and consequent erratic spray deposition, which sometimes adversely reduced budworm control and created hazards to other parts of the environment.

Studies were conducted by personnel of the Forest Insect Laboratory at Beltsville, Maryland, in the Deerlodge National Forest in 1956 and 1957 to resolve the question whether effective budworm control could be achieved from spray released higher than the recommended 200-400 feet over treetops. Data from the 1956 study indicated that insecticide released from a height of 750 feet above host forests reached the tree crowns in greater amounts than spray released from 500 or 250 feet. Budworm mortality seemed to be more nearly uniform over the areas where spray was dispersed from the 750-foot height (*U36*). However, a more careful trial of spraying at the 750-foot height over a 30,000-acre tract in 1957 produced irregular patterns of budworm mortality that were deemed unsatisfactory by standards then imposed. Because of this, the research team recommended that spraying be done at lower heights to assure maximum effectiveness (*U37*).

The presumed superior performance of small spray planes was refuted by flight tests in the Salmon National Forest in 1965. Flight characteristics and spraying patterns of the small planes (Stearman and CallAir) were compared with those of a former U.S. Navy TBM high-powered single-engine airplane commonly used for aerial spraying in both Forest Service Regions (*U194*). In addition to their inability to spray as much area as the TBM in the same amount of time, the small planes were faulted for their (1) higher average height of spraying, (2) more erratic spray swath patterns, (3) lack of reserve power to pull out of canyons having cramped flying space, and (4) more spraying time lost during frequent maneuvering to higher altitudes for pilot reorientation.

The Forest Service used aerially applied DDT for budworm control between 1952 and 1964 because no other chemical insecticides were as biologically effective, as reasonable in cost, as easily available, or as safe to use. Initial and continued use of DDT was based on (1) satisfactory experience with the compound's insecticidal qualities from New York (*U57*), eastern Canada (*U1*), and Oregon (*11, 35, U18*), and (2) satisfactory operational experience gained from spraying 2,260 acres of forest land in Oregon in 1945 (*78*) and 413,500 acres in Idaho in 1947 (*U95*).

Budworm control programs during 1952-1964 used a 12-percent DDT-oil solution that dispersed 1 pound of DDT in 1 gallon of the mixture per acre. The following formulation was most frequently used:

DDT (Dichlorodiphenyltrichloroethane), technical grade	1 pound
Hydrocarbon solvent	1.2 quarts
Fuel oil, diesel Type A, to make	1 gallon

This formulation was usually delivered to budworm control project airfields by commercial chemical suppliers in ready-to-use form. In the Intermountain Region, DDT formulations were usually mixed at the airstrip from which they were distributed.

In its report on the use of pesticides issued in May 1963, the President's Science Advisory Committee recommended that governmental agencies curtail use of persistent insecticides. Accordingly, the Forest Service turned to other insecticidal materials for controlling budworm outbreaks. The last time DDT was used against the budworm was in 1964 in the Salmon National Forest, when 485,870 acres of infested forest were aerially sprayed with 1 pound of the insecticide per acre. An additional 39,199 acres were sprayed with one-half pound of DDT per acre. Application of DDT at these two dosages achieved satisfactory reduction of budworm populations on 57 of the 62 spray blocks (*U206*).

Wildlife Protection Measures

Guidelines for operational budworm control programs usually were explicit in instructions to avoid spraying over defined areas deemed vital to human health and wildlife welfare. They outlined specific procedures for supervising spraying near these sensitive environments.

These precautionary measures included provisions for protecting honeybee colonies of commercial beekeepers in or near spray areas. Most beekeepers moved their colonies out of the vicinity of spray zones before spraying operations, or covered them during and immediately following spraying. Residual toxicity of DDT to honeybees normally persists from 3 hours to 1 day; malathion liquid sprays last from 3 to 7 hours (*115*).

The impact of DDT spraying on various constituents of the forest community was extensively studied in conjunction with several large-scale budworm control operations. Using the aerial spraying of a Douglas-fir tussock moth infestation in northern Idaho in 1947 (*U95*) as a model, pest control technicians from the USDA Forest Service and biologists from the Idaho and Montana fish and game departments investigated the effects of DDT residues on fish and animal populations following operational budworm control projects in 1956 and 1957 in sections of the Lewis and Clark, Helena, and Beaverhead National Forests and in several localities within the Salmon National Forest in 1963 and 1964 (*20, U35, U103*). Part of the investigations concerned with aquatic organisms were in streams flanked by nonspray zones 100 to 400 feet wide on either side of the waterways.

Data from these investigations supported several general conclusions concerning the effect of residues from the application of 1 pound of DDT per acre to budworm-infested forests:

1. Culinary quality of water from streams within or near spray areas was not impaired.

2. Natural or planted populations of trout, steelhead trout, and Chinook salmon were not harmed directly or from the buildup of DDT in fatty tissues.

3. Measurable amounts of DDT within spray zones immediately after spraying were not detected 1.5 miles downstream from these zones.

4. Aquatic invertebrate populations were drastically reduced by mortality within 24 hours after spraying; but there was natural restoration of these populations, in numbers if not in species, within 3 to 6 months or more after spraying.

5. Pre- and post-spray populations of forest birds on 40-acre plots were undifferentiated; this indicated neither mortality nor emigration from sprayed areas.

6. No acute losses of warmblooded animals were detected in or near spray zones.

7. Cream and grade A milk produced within and outside the spray zones showed no harmful amounts of DDT.

Even so, in some locales, fish, aquatic and terrestrial invertebrates, birds, and small animals were killed by their exposure to abnormally heavy quantities of DDT spray mixture. In these locales the toxicant was concentrated on vegetation, on the ground, or in streams and lakes from several spray plane crashes, from leaking spray plane nozzles over repeated flight routes, or from intentional dumping of spray loads by pilots who were experiencing in-flight malfunctions of their aircraft.

One most apparent and widespread ecological disturbance resulting from DDT spraying was the sudden appearance of epidemic infestations of the spruce spider mite. These epidemics first appeared in 1957 in Douglas-fir forests sprayed in 1956 to control budworm in parts of the Helena, Lewis and Clark, Deerlodge, and Beaverhead National Forests in Montana, and the Boise and Payette National Forests in Idaho (*58, U117*). Of the 885,000 acres of Douglas-fir type sprayed in Montana, 799,000 acres became infested with the mite in 1957. Of the 476,000 acres sprayed in 1956 in the two Idaho National Forests, 22,000 acres became mite-infested in 1957 (*U30, U278*). We believe that application of DDT, which is not toxic to the spruce spider mite, allowed its buildup by reducing populations of its effective predators. Chlorosis of host tree needles and the subsequent defoliation of host trees were at least as severe as much of the feeding damage caused by the budworm in the previous year.

The mite outbreaks spurred several surveys to determine the biology and abundance of mites in forest environments (*41, U96*). In response to the question whether use of DDT for budworm control should be continued, the Helena National Forest conducted an experimental spray program in 1958 using DDT and an acaricide, Genite, together to control the budworm and followup populations of the spider mite (*U119*). Results of the test were inconclusive because of the unforeseen collapse of spider mite populations from some natural cause.

These brief but spectacular outbreaks of the spruce spider mite attracted national and international interest of acarologists and forest insect control specialists. Rachel Carson (*19*) cited the occurrence of the spider mite outbreaks as one of a number of reasons for condemning DDT as an insecticide.

The decision in 1964 to stop using DDT for budworm control came at a time when outbreaks of this insect were exceptionally widespread. Epidemic infestations were tallied on 3.3 million acres of host types in the Northern Region and on 1.5 million acres in the Intermountain Region in 1965 (table 12). The need remained for protecting forest resource values in many parts of the infested acreage.

The organophosphate insecticide, malathion, was the first of several chemicals used to replace DDT for controlling the western spruce budworm. This nonpersistent insecticide was first applied experimentally at several dosage levels between 1963 and 1965 in parts of five National Forests in Idaho and Montana (table 19). Malathion was first used operationally in 1966 on 83,000 acres of budworm-infested Douglas-fir stands in the Beaverhead and Gallatin National Forests; it was sprayed at the rate of 13 fluid ounces per acre in its technically pure state without carrier (*U236, U288*).

The low-volume application of technical grade malathion in these two operational programs was done without benefit of spray deposit assessment from oil-sensitive dye cards or the planned use of the fluorescent tracer material, Leucophor C, which would have allowed the fine spray droplets to be traced and their deposits quantified. Since Leucophor C coagulated in mixture with the insecticide and clogged spray nozzles on the aircraft, it was omitted from the application. This difficulty has since been remedied.

Experimental Control Programs

Popular concern over ecology and environmental quality, so widely and energetically expressed during the 1960's, brought reactionary changes in the chemical control of the budworm. Among them were (1) curtailment of use of the persistent, broad spectrum insecticide, DDT; (2) accelerated field testing of substitute chemical insecticides more specific to the budworm, short-lived, and less harmful to other animal components of the budworm ecosystems; (3) laboratory testing of the insecticidal pathogen, *Bacillus thuringiensis* Berliner (*U52*); (4) trials of new techniques for aerial spray dispersal; and (5) more exacting control of aerial spray deposits in or near environmentally sensitive areas.

This last mentioned change was soon effected by recalling smaller aircraft to spray near the sensitive areas. Protection from spray residues was further increased by more stringent regulations for aerial spraying.

Other changes in control techniques quickly followed. By the mid-1960's, field testing in Montana was determining the effectiveness of newly developed aerially applied aerosol mist sprays to reduce budworm populations (*52, 53, 54*). Fluorescent tracers introduced into spray formulations to trace the positioning and amount of the minuscule spray droplets were also tested (*52, U177*).

An important change in policy for the chemical control of the budworm during this time was the decision by the Forest Service to find, test, and use insecticides that performed as effectively as DDT, but that maintained safety of the environment. To implement this, the Chemical Insecticide Evaluation Research Project was established in 1964 at the Pacific Southwest Forest and Range Experiment Station, Berkeley, California. The Project's mission was to screen candidate chemical insecticides for controlling insect pests of forest trees.

The screening process includes laboratory and field testing of insecticides that might prove to be (1) specifically toxic to a single target species, such as the budworm, (2) capable of quickly killing populations of that insect, (3) degradable to nontoxic substances within a few days after their application, and (4) adaptive to low-dosage aerial dispersal (*112*).

New-generation insecticides selected for budworm control by the Project's initial screening were carbaryl (Sevin), dimethoate (Cygon), mexacarbate (Zectran), pyrethrins, malathion, phosphamidon, and naled (Dibrom) (table 20). These insecticidal compounds were field-tested between 1964 and 1972 for their effectiveness in budworm control and for possible side effects in several National Forests in Idaho and Montana. Following is a summary of pertinent information yielded by these tests:

Malathion (Organic phosphate)

Malathion was first field-tested in Montana in 1963. One pound of malathion in fuel oil to make 1 gallon was applied at the rate of 1 gallon per acre. About this time, entomologists working with agricultural insect pests were finding that low-volume applications of technically pure malathion without solvents or carriers were effectively controlling epidemic populations of certain target insects. Beginning in 1964, similar low-volume applications of malathion were tested on western spruce budworm populations in several National Forests in Montana and Idaho. They were also used in 1966 in two operational budworm control programs in Montana.

The following tabulation summarizes history of the use of malathion against budworm populations in the northern Rocky Mountain and Intermountain areas:

Year	*National Forest*	*Malathion* (*Fluid oz/acre*)	*Fuel oil, to make* (*Gallons*)	*Budworm population reduction*[1] (*Percent*)	*References*
1963	Bitterroot	16	1	85	
		16	2	85	*U173*
1964	Lolo	9	None	88	*U204*
		12	1	83	*U287*
	Helena	12	1	81	*U287*
1965	Lewis and Clark	9	None	88	
		13	None	88	*U203*
	Salmon	9	None	71	
		13	None	90	*U194*
1966	Gallatin	13	None	87	*U236*
	Beaverhead[2]	13	None	97	*U288*

[1]Percentages listed here have not been corrected to allow for natural mortality.
[2]Cooperative project with the Bureau of Land Management on BLM lands outside of the National Forest. Host species: Rocky Mountain Douglas-fir.

Maximum percentages of budworm mortality resulting from malathion spray deposits were computed from 2 to 10 days after some test spraying. Pattee (*U194*) suggested that final determination of budworm mortality be delayed until 10 or 12 days after spraying on large-scale control programs involving low-volume applications of malathion.

Without fuel oil as part of low-volume applications, it was not possible to use oil-sensitive dye cards (*24, 25, 95*) to analyze the distribution patterns and amounts of malathion spray droplets, or, from them, to compute the amount of insecticide being deposited. In place of the dye cards, some malathion spray tests planned to use known numbers of solid, insoluble, micron-size, zinc-cadmium sulfide, fluorescent particles mixed in suspension with the liquid malathion (*52, 56*). The particles in the spray deposits, visible under ultraviolet light, are indicators of insecticide deposition on artificial targets or on the sprayed budworm larvae. However, problems were encountered in using fluorescent substances. The fluorescent dye Fluoral 7GA used with low-volume malathion spraying in 1965 remained visible in deposits under ultraviolet light for only as long as 2 hours after spraying (*U194*). In 1966, use of the fluorescent particle substance Leucophor C, when mixed with technical grade malathion, created a sludge that clogged aircraft spray nozzles and other parts of the spray system (*U289*). Because of these problems, most of the low-volume spraying with malathion was done without knowledge of the number and size of the spray droplets. Adequate spray deposition depended almost wholly on good orientation by spray plane pilots and on close supervision of spraying operations by aerial observers. This presumably was effective because the budworm mortality achieved by most low-volume malathion spray projects was generally satisfactory.

Application of low-volume malathion, with or without oil carriers and without fluorescent tracers, cost approximately $1.50 per acre as used on nearly 250,000 acres in Montana and Idaho. Per-acre cost of similar spraying on two smaller projects totaling only 11,000 acres, however, averaged approximately $5.00.

Measurements or observations were made on each malathion spray program to determine the effects of the deposited insecticide on aquatic invertebrates and fish in streams within or near the spray zones and on song and upland game birds and animals in these zones. Data collected from these surveillances were often inconclusive because of poor experimental design, unforeseen weather phenomena, or erratic spraying.

The more substantial measurements indicated that low-volume malathion spraying, with reasonable avoidance of streams, caused (1) immediate but temporary drifting (attempt to leave a particular stretch of stream) and some killing of aquatic invertebrates, (2) little damaging inhibition of cholinesterase in fish, and (3) little observed stress or mortality of fish from malathion deposits that drifted, or were inadvertently sprayed, into the water of streams within the spray zones (*U194, U298, U299*).

Observations on the reactions or distress of song birds or animals from low-volume deposits of malathion spray were mostly inconclusive, albeit no adverse effects were recorded. Attempts to record adverse effects of the spraying on caged fish and pheasants were voided because the test animals died before the spraying.

Mexacarbate (Carbamate)

Laboratory tests by the Chemical Insecticide Evaluation Project indicated that the carbamate insecticide mexacarbate (trade name Zectran) was one of the most effective and ecologically acceptable of the present-day chemicals that might be used to control budworm.

Mexacarbate appears especially suited for this task because (1) it can produce high rates of mortality in budworm larval populations; (2) it is highly toxic against sixth-instar budworm larvae (100 times greater than DDT); and (3) it appears to have little adverse effect on forest environments because of its specificity to the budworm, its rapid rate of chemical detoxification after aerial application, and its relatively low hazard to aquatic and other terrestrial biological systems (table 20). Present disadvantages are its relatively high cost but, more important, its frequently unsatisfactory field performance, a residual life that probably is too short, and a rather low registered dose for the variable field conditions in which it is used.[18]

Additional studies of usefulness of mexacarbate indicated that it can be applied effectively in the field in small dosages and as aerosol sprays with droplets smaller than 50 microns median mass diameter (m.m.d.) (*53, 54, 55*).

Several formulations of mexacarbate were applied aerially by the USDA Forest Service between 1964 and 1971 in operation-simulated field tests in the Northern and Intermountain Regions. In addition to determining its toxic effectiveness at low-dosage rates, the tests evaluated the efficiency of spray plane bifluid systems using atomizing fluids for these low rates, for small droplet emissions, and for spray dispersal patterns. These tests also measured effectiveness of fluorescent tracers in spray formulations (*U177*) and of a neodymium lidar transmitter (*88, U34*) for detecting and quantifying the dispersal and placement of spray deposits.

---

[18]Bohdan Maksymiuk, Pacific Northwest Forest and Range Experiment Station, Forestry Sciences Laboratory, Corvallis, Oregon. Personal communication.

Formulations most frequently used in these tests consisted of mexacarbate (technical grade) 2.4 ounces (0.15 pound) in one gallon of solution composed of a solvent (Dowanol TPM), 1 part, and a carrier (deodorized kerosene, or cycle oil), 9 parts. One gallon of this mixture was usually applied to each acre of infested forest.

The several experimental applications of mexacarbate reduced populations of budworm on National Forests in Idaho and Montana as shown below.

Year	*National Forest*	*Mexacrabate* *(Oz/acre)*	*Acres treated*	*Budworm Population reduction*[1] *(Percent)*	*References*
1964	Salmon	1.6	60	[2] NA	*U289*
1965	Bitterroot	2.4	1,080	92	*118*
1966	Salmon	2.4	4,860	[3] 100	*U176*
	Bitterroot	2.4	5,360	[4] 35	*U104*
1967	Sawtooth	2.4	2,300	94	*88, U7*
1968	Lolo	1.0	6,080	59	*U182*
1969	Nezperce	2.4	6,000	56	*U290*
1971	Nezperce	2.4	9,000	48	*30*

[1] Not corrected for natural mortality.
[2] Not available; reduction considered unsatisfactory.
[3] Natural budworm mortality 98 percent on unsprayed check area; test inconclusive.
[4] Natural budworm mortality 46 percent on unsprayed check area.

Disappointingly low budworm mortality from most of the above mexacarbate applications was attributed to (1) low-level budworm populations that increased the difficulty of statistically differentiating the abundance of prespray and postspray and of treated and untreated budworm numbers, (2) high natural mortality of budworm larvae at the time of spraying, (3) unseasonable rapid development of budworm larvae prior to spraying, (4) malfunctions of spraying equipment, or (5) poor distribution and placement of spray deposits.

Laboratory screening in Berkeley established the suitability of mexacarbate for budworm control on operational scale. But, as Dewey and others pointed out (*30*), its effectiveness depends on getting adequate deposits of the chemical to the target trees. Fluorescent tracers (*U177*) revealed wide variation in mexacarbate deposits both within and between target trees. The tracers also disclosed a good correlation between the amount of spray deposited and the amount of budworm mortality. This implies that good budworm mortality can be achieved with the small-micron spray droplets of mexacarbate where the spray is deposited in recommended amounts.

The low-dosage application of mexacarbate in the Nezperce National Forest in 1971 did not seriously reduce the abundance of major insect parasites of the budworm (*30*). The percentage of budworm larvae parasitized by *Apanteles fumiferana* increased slightly but significantly between prespray and 8-day postspray larval samples. Parasitizing by *Glypta fumiferana* and tachinids did not increase appreciably.

The specificity of mexacarbate to the budworm and two other forest pests was demonstrated by experimental spraying in the Bitterroot National Forest in 1965 (*118*). Mexacarbate reduced populations of larch bud moth (*Zeiraphera griseana*) and a sawfly (*Neodiprion* sp.) more than those of the budworm, but it did not greatly reduce populations of the western hemlock looper (*Lambdina fiscellaria lugubrosa*) and another unidentified looper.

The effects of aerial applications of mexacarbate on wildlife were surveyed on several of the pilot tests of this chemical. Fisheries biologists reported no apparent detrimental effects on populations of native trout after mexacarbate was purposely sprayed over a stream in the Bitterroot National Forest in 1966 (*U104*). They observed only slight increase in the number of drifting aquatic insects in the sprayed portion of the stream. In a nearby stream where a bordering forest strip had been sprayed by helicopter to reduce adverse effects of the chemical to fish and aquatic invertebrates, postspray drift of insects was as great as in the sprayed stream, but fish suffered no apparent ill effects.

A 240-acre study plot established as part of the 1966 Bitterroot National Forest mexacarbate test was sprayed on 2 consecutive days with five applications of 0.15 pound per acre of the chemical to observe possible effects of the toxicant on native grouse. Preliminary analysis of information developed by this test indicated no harmful effects to grouse during or following application (*U104*).

Wildlife research biologists studied the reactions of birds and mammals to experimental spraying of mexacarbate in the Bitterroot National Forest in 1965 and 1966, in the Salmon National Forest in 1966, and in the Sawtooth National Forest in 1967. The first three treatments were aerial spraying of 2.4 ounces of mexacarbate in 1 gallon of oil carrier per acre. The Sawtooth study used an aerosol spray of 1 ounce of mexacarbate in 1 pint of oil carrier per acre.

The biologists reported that 3 years' study of mexacarbate residues showed no detrimental effects on wildlife (*81*), but added that the studies did not prove safety in the use of this chemical. They also observed that:

1. The mexacarbate applications resulted in no harm or reduction in birds or mammals in the areas studied.

2. The spray temporarily increased the availability of budworm larvae and other insect food.

3. The reduction in the insect food supply that followed this increase did not cause nest abandonment or interfere with the rearing of young birds.

4. Only one chipmunk showed any effect that could be attributed to the spray--a temporary but marked increase in respiration on the day of spraying.

5. Several golden-mantled ground squirrels taken the day after the spraying had stomachs packed with budworm larvae; one contained at least 179 larvae.

6. During the summer of 1966, both red squirrels and chipmunks were apparently foraging for budworm larvae at the tips of Douglas-fir branches.

7. Ground squirrels, chipmunks, and a deer mouse collected within a day after spraying on one study area had fluorescent particles from the spray in their pelage and intestinal tracts; all contained some budworm remains, but the chipmunks contained the most.

Phosphamidon (Organic Phosphate)

Five thousand acres of privately owned budworm-infested Douglas-fir forest in the Blackfoot River drainage of western Montana were sprayed with a water emulsion of phosphamidon in 1963 (*U227*). A cooperative undertaking by the USDA Forest Service and Anaconda Forest Products, owner of the timberlands, was an experimental application designed to determine (1) the practical effectiveness of the insecticide on the budworm, (2) its toxicity to stream habitat invertebrates and trout, and (3) the possible correlation between the number of spray droplets deposited on sample dye cards and the mortality of budworm larvae on nearby host tree foliage.

The rapid hydrolizing and metal corrosive actions of phosphamidon required that formulations of the insecticide be limited in amount to the equivalent of one spray plane load at a time, about 350 gallons. The following formulation was used, in the order of the listed ingredients:

Water	311 gallons
Methylene blue dye	35.5 grams
Sodium bisulphate, to lower the pH of the water from 7.8 to 7.6	2.7 ounces
Phosphamidon, technical grade, liquid	39 gallons

This mixture, sprayed over the test forest at the rate of 1 pound of phosphamidon per acre, reduced larval populations of the budworm by 71 percent as measured 4 days after spraying. This percentage of budworm mortality was considered inadequate.

Stream bottom and drift samples indicated no measurable loss of aquatic invertebrates inside of or downstream from the spray zone. Rainbow and cutthroat trout in live cars above, within, and below the sprayed area suffered no apparent distress or mortality.

Blood samples from several grouse found dead within the sprayed area showed evidence of organic phosphate poisoning. Grouse in a stupefied condition, presumably from effects of the insecticide, were easily captured in the same area; but other grouse observed in the spray zone appeared to be healthy and unaffected by the spray. Forest-inhabiting birds in the sprayed area were estimated by a wildlife biologist to be about one-fourth those observed prior to spraying.

Terrell (*U227*) found no correlation between the number of spray droplets deposited on sample dye cards and the amount of budworm larval mortality on surrounding Douglas-fir foliage. Maksymiuk *(69)* also observed this negative relationship after using a DDT-oil spray in tests in Montana and Maine.

Only authorized personnel in special protective clothing were allowed at the insecticide mixing facility at the airfield because of the high toxicity of phosphamidon.

Carbaryl (Carbamate)

The carbamate insecticide carbaryl, known by its trade name Sevin, was field-tested on 9,960 acres of budworm-infested Douglas-fir in the Targhee National Forest during July 1963 (*111, U286*). Since carbaryl had been effective against other forest insect pests elsewhere, it was important to learn its action against the budworm. Specifically, the trial of this relatively new toxicant was undertaken to determine its ability to reduce epidemic populations of the budworm when aerially applied at dosage rates of 1.6 pounds and 0.8 pound in 1-1/2 gallons of water per acre.

The water-soluble fluorescent dye tracer Leucophor C was added in the amount of 1 percent of the carbaryl-water spray mixture. The dye was used in addition to spray deposit cards to measure spray deposition. The test was inconclusive because most of the water-soluble carbaryl was apparently washed from the foliage of sprayed trees by heavy thundershowers shortly after its deposition. In the short interval between the spraying and the rainstorm, no appreciable knockdown of budworm larvae was observed. Postspray sampling showed that larval populations were virtually equal to prespray populations.

Fluorescent particles presumably washed from tree foliage by the rains were readily detected on the forest floor. Their sparseness along a streambank indicated that efforts to keep the spray out of the water apparently had been successful.

Dimethoate (Organic Phosphate)

Dimethoate, a candidate insecticide for controlling the budworm, was aerially applied in the South Fork Iron Creek drainage of the Salmon National Forest in July 1964 (*U6, U175*). A formulation of one-fourth pound of the toxicant in 1 gallon of cycle oil was applied at the rate of 1 gallon per acre over 1,080 acres of Douglas-fir trees. Insecticidal action of the dimethoate was slow, as evidenced by a lack of immediate postspray knockdown of budworm larvae and the absence of distressed or dead larvae on the ground under sprayed trees for 5 or 6 days after spraying.

The increasing percentages of mortality of budworm larvae reported from 5 to 20 days after spraying may be attributed to possible systemic action of the dimethoate, as follows:

Postspray sample period	*Larval mortality* (*Percent*)
5th day	37
10th day	44
15th day	44
20th day	56

These low percentages of larval mortality were inadequate reduction of budworm populations.

Naled (Organic Phosphate)

The organophosphate insecticide naled was tested for capability to reduce budworm populations by spraying on 1,165 acres of host forests in the Mud Creek drainage of Bitterroot National Forest in July 1965 (*118*). Naled was applied in a low-volume concentrate in ethylene glycol at the rate of 0.41 pound (0.82 pint of the toxicant) per acre from a helicopter.

Since naled is less persistent than DDT,[19] it was hoped that this test would show it to be highly effective against all larval instars of the budworm at the time of spraying to match the overall effectiveness of DDT. This effectiveness was not achieved. Postspray samples of sixth-instar larvae showed less mortality than treated larvae in the fourth and fifth instars.

---

[19]Residues of DDT applied aerially during the fourth larval instar of the budworm have remained highly toxic for a week or more. Their toxicity is therefore effective against larvae of the current generation emerging late from diapause. They may still be toxic to first-instar budworm larvae of the succeeding generation (*118*).

The average percentage of budworm mortality from naled sprayed on three host tree species was:

Tree species	*Budworm larval mortality* (*Percent*)
Subalpine fir	62
Douglas-fir	34
Engelmann spruce	73
All species, weighted	43

Pyrethrins (Organic, Botanical)

Pyrethrins, which are excellent insecticides, are derived from pyrethrum flowers of the genus *Chrysanthemum*; they may also be synthesized from other chemicals.

Three formulations of a pyrethrin compound were applied to as many 20-acre test plots in the Williams Creek drainage of the Salmon National Forest in July 1964.[20] The insecticide presumably was deposited on budworm-infested Douglas-fir trees by helicopter and fixed-wing aircraft. The formulations used and the budworm larval mortality attributed to each were:

Pyrethrin formulation and dosage per acre	*Budworm larval mortality* (*Percent*)
1. Pyrethrins, 0.03 pound, in water, 2 gallons per acre, applied as an invert emulsion	0-19
2. Pyrethrins, 0.01 pound, in #2 fuel oil, 1 gallon per acre	11-48
3. Pyrethrins, no amount recorded, in water, 2 gallons per acre	0-18

Observations indicated that drifting of the spray may have caused much of the insecticide to be deposited outside of the plot areas.

Dichlorovos (DDVP) (Organic Phosphate)

A formulation containing 0.1 pound of dichlorovos in 1 gallon of #2 fuel oil was applied by helicopter at the rate of 1 gallon per acre on a 20-acre sample plot in the Williams Creek drainage in Salmon National Forest in July 1964 to test its insecticidal value on a larval population of the budworm. The application did not reduce the larval population on the sprayed area.

---

[20]Galen C. Trostle, Entomologist and Head, Section of Forest Insect Control, Division of Timber Management, USDA Forest Service, Intermountain Region, Ogden, Utah. Personal communication.

PROSPECTS FOR FUTURE OUTBREAKS

Ranger district reports of outbreaks, continuing infestation, and experiments devised to develop effective controls for the western spruce budworm have provided abundant useful information that covers 50 years. Despite the numerous studies and experiments, though, we face two unpleasant facts: the budworm is still rampant, and nearly 5 million acres of forests in the northern Rocky Mountain area are still infested.

Foresters and entomologists have been collecting information about biology and control of this budworm during five decades, but we are still hunting for effective ways to prevent sudden devastating outbreaks and for infallible methods for controlling outbreaks that may occur--methods at once biologically effective and ecologically acceptable. We do not know precisely what conditions trigger outbreaks, keep them going, or terminate them. We have not learned to recognize these conditions or measure their magnitude in time to be at least forewarned of impending explosions of populations of this insect. In short, we simply do not know when or where the next outbreaks will appear nor what their impact is likely to be on the varied resource values of the host forests.

Review of the long record of past outbreaks reveals absence of several kinds of information that could be supplied by concerted effort in research by pest control entomologists--information that would enable forest managers in the West to prevent massive outbreaks of the budworm or to reduce the impact of any that might occur. These two objectives could be achieved:

1. Through more knowledge of the biological and environmental factors that affect the population dynamics of the budworm, and through means of monitoring these factors in localities where outbreaks are presumed most likely to occur.

2. Through recognition of conditions in host forests that foster and support the development and maintenance of epidemic budworm populations for abnormally long periods, along with effective methods and the capital needed to regulate those conditions so as to reduce the susceptibility of these forests.

3. Through development of adequate methods for evaluating the economic and ecologic impacts of budworm outbreaks on the multiple or single uses for which individual forests are managed; these evaluations, in turn, to be bases for management decisions that must consider long-term preventive control or current applied control measures.

4. Through availability of assured, standardized techniques for subduing current outbreaks; these techniques to be operationally feasible and subject to controls that at once guarantee their biological effectiveness and preserve the normal harmony of forest ecosystems.

5. Through clearer realization by forest managers of the biological complexity and the general importance of budworm control.

We feel that attainment of these objectives within a reasonably short time is necessary if the management of forests in the northern Rocky Mountain area is to proceed uninterrupted by occasional devastating outbreaks of the budworm.

REFERENCES

1. Anonymous
   1930. Current news notes. J. Econ. Entomol. 23(3):652.
2. Baker, Bruce H.
   1969. Forest insect and disease conditions in the Intermountain States during 1968. USDA For. Serv., Intermt. Reg., Ogden, Utah, 18 p., illus.
3. Baker, Frederick S.
   1950. Principles of silviculture. 414 p. McGraw-Hill Book Co., New York.
4. Bedard, W. D.
   1938. An annotated list of the insect fauna of Douglas-fir (*Pseudotsuga mucronata* Rafinesque) in the northern Rocky Mountain region. Can. Entomol. 70(9): 188-197.
5. Blais, J. R.
   1962. Collection and analysis of radial-growth data from trees for evidence of past spruce budworm outbreaks. For. Chron. 38(4):474-484.
6. Blais, J. R.
   1965. Spruce budworm outbreaks in the past three centuries in the Laurentide Park, Quebec. For. Sci. 11(2):130-138.
7. Blickenstaff, C. C.
   1970. Proposed addition to the list of common names of insects approved by the Entomological Society of America. Bull. Entomol. Soc. Am. 16(3):168-169.
8. Bongberg, J. W.
   1958. Forest insect surveys in the United States. Tenth Int. Congr. Entomol. Proc. 1956, 4:193-199.
9. Bongberg, J. W.
   1959. Biological evaluation of outbreaks of forest insects. J. For. 57:287.
10. Boyce, John Shaw
    1961. Forest pathology. 3rd ed. 572 p. McGraw-Hill Book Co., New York.
11. Brockman, C. F., and D. W. Berry
    1950. The Chesnimnus experimental spruce budworm control project. Oreg. State Board For., Res. Bull. 5, 23 p., illus.
12. Brown, A. W. A.
    1951. Insect control by chemicals. 817 p. John Wiley and Sons, New York.
13. Brown, C. E.
    1970. A cartographic representation of spruce budworm *Choristoneura fumiferana* (Clem.), infestation in eastern Canada, 1909-1966. Can. Dep. Fish. and For., For. Serv., Ottawa, Publ. 1263, 4 p.
14. Buckner, C. H.
    1966. The role of vertebrate predators in the biological control of forest insects. Annu. Rev. Entomol. 11:449-470.
15. Buffam, Paul E., and V. M. Carolin
    1966. Determining trends in western spruce budworm egg populations. J. Econ. Entomol. 59(6):1442-1444.
16. Büsgen, M., and E. Münch
    1931. The structure and life of forest trees. (Engl. Transl. by Thomas Thomson.) 436 p. John Wiley and Sons, New York.
17. Carolin, V. M., and W. K. Coulter
    1959. The occurrence of insect parasites of *Choristoneura fumiferana* (Clem.), in Oregon. J. Econ. Entomol. 52(4):550-555.

18. Carolin, V. M., and W. K. Coulter
1971. Trends of western spruce budworm and associated insects in Pacific Northwest forests sprayed with DDT. J. Econ. Entomol. 64(1):291-297.
19. Carson, Rachel
1962. Silent spring. 368 p. Houghton Mifflin, Boston.
20. Casebeer, Robert L.
1965. Monitoring the 1964 spruce budworm aerial spray project, Salmon National Forest [Idaho]. USDA For. Serv. [Intermt. Reg.], Ogden, Utah, 133 p., illus.
21. Ciesla, William M., Mark D. McGregor, and Wayne E. Bousfield
1971. Forest insect conditions in the Northern Region, 1970. USDA For. Serv., Missoula, Mont., 12 p., illus.
22. Ciesla, W. M., M. D. McGregor, and S. Tunnock
1972. Forest insect conditions, 1971, Northern Region. USDA For. Serv. [Northern Reg.], Missoula, Mont., 14 p., illus.
23. Craighead, F. C.
1924. General bionomics and possibilities of prevention and control. *In*: Studies on the spruce budworm (*Cacoecia fumiferana* Clem.). Can. Dep. Agric., Ottawa, Bull. 37 (N.S.), 139 p., illus.
24. Davis, J. M.
1953. Standards for estimating airplane spray deposit on oil-sensitive cards. USDA Dep. Agric., For. Serv. [Beltsville, Md.].
25. Davis, J. M., and K. R. Elliott
1953. A rapid method of estimating aerial spray deposits. J. Econ. Entomol. 46(4):696-698.
26. Davis, J. M., W. E. Waters, D. A. Isler, R. Martineau, and J. W. Marsh
1956. Experimental airplane spraying for spruce budworm control. J. Econ. Entomol. 49(3):338-341.
27. Denton, Robert E.
1953. The spruce budworm problem in the northern Rocky Mountains. Northwest Sci. 27(2):67-72.
28. Dewey, Jerald E.
[1968]. Forest insect conditions in the Northern Region, 1967. USDA For. Serv. [North. Reg.], Missoula, Mont., 11 p., illus.
29. Dewey, Jerald E.
1970. Damage to Douglas-fir cones by *Choristoneura occidentalis*. J. Econ. Entomol. 63(6):1804-1806.
30. Dewey, Jerald E., William M. Ciesla, and Mark D. McGregor
[1972]. The 1971 western spruce budworm pilot test, Nezperce National Forest and Idaho State lands. USDA For. Serv., Missoula, Mont., 20 p., illus.
31. Dodge, Harold R.
1957. Defoliating insects in the northern Rocky Mountains in 1955. Northwest Sci. 31(1):38-42.
32. Dodge, Harold R.
1961. Parasitism of spruce budworm by *Glypta* and *Apanteles* at different crown heights in Montana. Can. Entomol. 93(3):222-228.
33. Dodge, Harold R., Tom T. Terrell, and Philip C. Johnson
1956. Entomological phases of the 1955 Montana spruce budworm control project. USDA For. Serv., Intermt. For. and Range Exp. Stn., Misc. Publ. 9, 12 p.
34. Dowden, Philip B., W. D. Buchanan, and V. M. Carolin
1948. Natural-control factors affecting the spruce budworm. J. Econ. Entomol. 41(3):457-464.
35. Eaton, C. B., J. A. Beal, R. L. Furniss, and C. F. Speers
1949. Airplane and helicopter spraying with DDT for spruce budworm control. J. For. 47(10):823-827.
36. Evenden, James C.
1923. Eastern spruce budworms in the West. The Timberman 25(2):53-54, illus.

37. Evenden, James C.
1923. The spruce budworm in northern Idaho. USDA For. Serv., Priest River Exp. Stn., Missoula, Mont., Appl. For. Note 37, 3 p.
38. Evenden, James C.
1923. Spruce budworms in northern Idaho. The Timberman 24(4):48, illus.
39. Evenden, James C.
[1927]. Information on the spruce budworm in Idaho and Montana. USDA Bur. Entomol., Wash., D.C., For. Entomol. Brief 64, 2 p.
40. Fauss, David L., and William R. Pierce
1969. Stand conditions and spruce budworm damage in a western Montana forest. JJ. For. 67(5):322-325.
41. Fellin, David G.
1968. Mites collected from Douglas-fir foliage in Montana. J. Econ. Entomol. 61(3):877-878.
42. Fellin, David G., and Wyman C. Schmidt
1967. Spruce budworm larvae sever stems of western larch shoots in Montana. J. For. 65(4):258-260, illus.
43. Fellin, David G., and Wyman C. Schmidt
1972. Frost reduces western spruce budworm populations and damage in Montana. Agric. Meteorol. 11:277-283.
44. Fellin, David G., and Wyman C. Schmidt
1973. How does western spruce budworm feeding affect larch? USDA For. Serv. Gen. Tech. Rep. INT-7, 25 p., illus.
45. Fellin, David G., and Raymond C. Shearer
1968. Spruce budworm larvae damage western larch cones and seeds. J. For. 66(7): 568-570, illus.
46. Fowells, H. A. (Comp.)
1965 Silvics of forest trees of the United States. U.S. Dep. Agric., Agric. Handb. 271, 762 p, illus.
47. Freeman, T. N.
1967. On coniferophagous species of Choristoneura (Lepidoptera: Tortricidae) in North America. I. Some new forms of *Choristoneura* allied to *C. fumiferana*. Can. Entomol. 99(5):449-455, illus.
48. Furniss, Malcolm M.
1957. Entomological aspects of the 1955 southern Idaho spruce budworm control project. USDA For. Serv., Intermt. For. and Range Exp. Stn. Misc. Publ. 10, 22 p., illus.
49. Graham, Samuel Alexander
1952. Forest entomology. 3d ed. 351 p. McGraw-Hill Co., New York.
50. Greenbank, D. O.
1956. The role of climate and dispersal in the initiation of outbreaks of the spruce budworm in New Brunswick. 1. The role of climate. Can. J. Zool. 34(5):453-476.
51. Hewitt, C. Gordon
1911. Report of the Dominion Entomologist for the year ending March 31, 1911. *In*: Annual report on experimental farms for the year 1910-11, Can. Dep. Agric., Ottawa, p. 231-233, illus.
52. Himel, Chester M.
1969. The fluorescent particle spray droplet tracer method. J. Econ. Entomol. 62(4):912-916.
53. Himel, Chester M.
1969. The optimum size for insecticidal spray droplets. J. Econ. Entomol. 62(4): 919-925.
54. Himel, Chester M., and Arthur D. Moore
1967. Spruce budworm mortality as a function of aerial spray droplet size. Science 156:1250-1251.
55. Himel, Chester M., and Arthur D. Moore
1969. Spray droplet size in the control of spruce budworm, boll weevil, bollworm, and cabbage looper. J. Econ. Entomol. 62(4):916-918.

56. Himel, C. M., L. Vaughn, R. P. Miskus, and A. D. Moore
1965. A new method for spray deposit assessment. USDA For. Serv. Res. Note PSW-87, 10 p.
57. Honing, Frederick W.
[1969]. Forest insect conditions in the Northern Region, 1968. USDA For. Serv. [North. Reg.], Missoula, Mont., 14 p., illus.
58. Johnson, Philip C.
1958. Spruce spider mite infestations in northern Rocky Mountain Douglas-fir forests. USDA For. Serv., Intermt. For. and Range Exp. Stn. Res. Pap. 55, 14 p., illus.
59. Klein, William H.
1967. Forest insect conditions in the Intermountain States during 1966. USDA For. Serv. [Intermt. Reg.], Ogden, Utah, 17 p., illus.
60. Klein, William H.
1968. Forest insect conditions in the Intermountain States during 1967. USDA For. Serv. [Intermt. Reg.], Ogden, Utah, 20 p., illus.
61. Klein, William H., and Mark D. McGregor
1966. Forest insect conditions in the Intermountain States during 1965. USDA For. Serv. [Intermt. Reg.], Ogden, Utah, 13 p., illus.
62. Klein, William H., and Alfred C. Tegethoff
1970. Forest insect and disease conditions in the Intermountain States during 1969. USDA For. Serv., Ogden, Utah, 11 p., illus.
63. Kramer, Paul J., and Theodore T. Kozlowski
1960. Physiology of trees. 642 p. McGraw-Hill Book Co., New York.
64. Lang, Jean M.
1970. Reduction in the fertility of female *Choristoneura occidentalis* by Lannate. J. Econ. Entomol. 63(5):1619-1621.
65. Larsen, J. A.
1930. Forest types of the northern Rocky Mountains and their climatic controls. Ecology 11(4):631-672.
66. Macdonald, D. R.
1968. Management of spruce budworm populations. For. Chron. 44(3):33-36, illus.
67. Maksymiuk, Bohdan
1959. Improved holders for spray deposit assessment cards. J. Econ. Entomol. 52(5):1029-1030.
68. Maksymiuk, Bohdan
1963. Screening effect of the nearest tree on aerial spray deposits recovered at ground level. J. For. 61(2):143-144.
69. Maksymiuk, Bohdan
1963. Spray deposit on oil-sensitive cards and spruce budworm mortality. J. Econ. Entomol. 56(4):465-467.
70. Maksymiuk, Bohdan, and A. D. Moore
1962. Spread factor variation for oil-base, aerial sprays. J. Econ. Entomol. 55(5):695-699.
71. McKnight, Melvin E.
1965. A review of the literature on the spruce budworm, *Choristoneura fumiferana* (Clemens). USDA For. Serv., Rocky Mt. For. and Range Exp. Stn., 131 p.
72. McKnight, Melvin E.
1967. Ecology of the western budworm, *Choristoneura occidentalis* Freeman (Lepidoptera: Tortricidae), in Colorado. Master's Thesis, Colo. State Univ., Fort Collins, 206 p., illus.
73. McKnight, M. E.
1968. A literature review of the spruce, western, and 2-year-cycle budworms *Choristoneura fumiferana*, *C. occidentalis*, and *C. biennis* (Lepidoptera: Tortricidae). USDA For. Serv. Res. Pap. RM-44, 35 p.
74. McKnight, M. E.
1969. Distribution of hibernating larvae of the western budworm, *Choristoneura occidentalis*, on Douglas-fir in Colorado. J. Econ. Entomol. 62(1): 139-142, illus.

75. McKnight, M. E.
1971. Biology and habits of *Bracon politiventris* (Hymenoptera: Braconidae). Ann. Entomol. Soc. Am. 64(3):620-624, illus.
76. Morris, R. F. (ed.)
1963. The dynamics of epidemic spruce budworm populations. Entomol. Soc. Can. Mem. 31, 332 p.
77. Odum, Eugene P.
1959. Fundamentals of ecology. Ed. 2. 546 p. W. B. Saunders Co., Philadelphia.
78. Olson, Harold
1946. Blitzing the hemlock looper. Nat. Mag. 39:34-36,50.
79. Parker, Douglas L., and Alfred C. Tegethoff
1971. Forest insect and disease conditions in the Intermountain States during 1970. USDA For. Serv., Ogden, Utah, 10 p., illus.
80. Parker, Douglas L., Lawrence E. Stipe, and Alfred C. Tegethoff
1972. Forest insect and disease conditions in the Intermountain States, 1971. USDA For. Serv., Ogden, Utah, 10 p., illus.
81. Pillmore, R. E., E. L. Flickinger, and M. L. Richmond
1971. Forest spraying of Zectran and its safety to wildlife. J. For. 69(10): 721-727.
82. Rorig, G.
[1899]. Ansammlungen von Folgehn in Nonnenrevieren. Ornith. Mschr., No. 2. [Flocks of crows, among other birds, were observed in an area of nun moth infestation feeding on larvae of the moth.]
83. Schmidt, Wyman C., and David G. Fellin
1972. Western spruce budworm damage affects form and height growth of western larch. Can. J. For. Res. 3:17-26.
84. Shelford, Victor E.
1963. The ecology of North America. 610 p. Univ. Illinois Press, Urbana.
85. Shilova-Krassova, S. A.
1953. The activity of insectivorous birds in areas mass-infested with forest insects. Zool. Z. 32(5):955-963. (Transl. from Russ.) [Cuckoos and orioles were among the main avian predators of lacky moth larvae on oak; other birds (crows) preyed on *Malacosoma neustria* L.]
86. Silver, G. T.
1960. Notes on a spruce budworm infestation in British Columbia. For. Chron. 36(4):362-374.
87. Swaine, J. M., and F. C. Craighead
1924. Studies on the spruce budworm (*Cacoecia fumiferana* Clem.). Can. Dep. Agric. Bull. 37, N.S., Part I, 27 p., illus.
88. Taynton, Shag [Roger]
[1968]. The 1967 Big Smoky spruce budworm zectran project. USDA For. Serv., Sawtooth Natl. For., Twin Falls, Idaho, 48 p., illus.
89. Terrell, Tom T.
1959. Northern Rocky Mountain reports budworm down, other insects up. West. Conserv. J. 16:52-53,69, illus.
90. Terrell, Tom T.
1959. Sampling populations of overwintering spruce budworm in the northern Rocky Mountain region. USDA For. Serv., Intrmt. For. and Range Exp. Stn. Res. Note 61, 8 p., illus.
91. Terrell, Tom T.
1961. Estimating defoliation caused by spruce budworm from undamaged shoots. USDA For. Serv., Intermt. For. and Range Exp. Stn. Res. Note 86, 2 p.
92. Terrell, Tom T.
1966. Spruce budworm survey methods in the Northern Region. USDA Agric. Res. Serv., Coop. Econ. Insect Rep. 16(46):1071-1072.
93. Thornbury, John R., and Robert E. Denton
1972. Low kilovoltage radiography in the detection of parasites of the western spruce budworm, *Choristoneura occidentalis*. Ann. Entomol. Soc. Am. 65(5): 1232-1235.

94. Thornbury, William D.
1965. Regional geomorphology of the United States. 609 p. John Wiley & Sons, New York.

95. Thornton, D. G., and J. M. Davis
1956. A method of sampling for the drop size of aerial spray deposits. J. Econ. Entomol. 49(1):80-83.

96. Tiernan, C. F., and R. P. Miskus
1971. Toxicity of Zectran to western spruce budworm as a function of application site. J. Econ. Entomol. 64(5):1307-1308.

97. Tucker, Richard K., and D. Glen Crabtree
1969. Toxicity of Zectran insecticide to several wildlife species. J. Econ. Entomol. 62(6):1307-1310.

98. Tunnock, Scott
1963. Forest insect conditions in the Northern Region, 1963. USDA For. Serv. [North. Reg.], Missoula, Mont., 12 p., illus.

99. Tunnock, Scott, and Harvey V. Toko
1965. Forest insect and disease conditions in the Northern Region, 1964. USDA For. Serv. [North. Reg.], Missoula, Mont., 18 p., illus.

100. Tunnock, Scott, Harvey V. Toko, and Tom T. Terrell
1966. Forest insect and disease conditions in the Northern Region, 1965. USDA For. Serv. [North. Reg.], Missoula, Mont., 19 p., illus.

101. U.S. Forest Service
[1955]. 1955 spruce budworm control, southwest Idaho. USDA For. Serv., Intermt. Reg., Ogden, Utah, 30 p., illus.

102. U.S. Forest Service
[1956]. 1956 spruce budworm control, southern Idaho. USDA For. Serv., Intermt. Reg., Ogden, Utah, 25 p., illus.

103. U.S. Forest Service
1957. Forest insect conditions in the Intermountain and northern Rocky Mountain States during 1956. USDA For. Serv., Intermt. For. and Range Exp. Stn., Misc. Publ. 11, 6 p.

104. U.S. Forest Service
[1957]. 1957 spruce budworm control, southwest Idaho. USDA For. Serv., Intermt. Reg., Ogden, Utah, 26 p., illus.

105. U.S. Forest Service
1958. Forest insect conditions in the Intermountain and northern Rocky Mountain States during 1957. USDA For. Serv., Intermt. For. and Range Exp. Stn., Misc. Publ. 13, 11 p., illus.

106. U.S. Forest Service
1959. Forest insect conditions in the Intermountain and northern Rocky Mountain States during 1958. USDA For. Serv., Intermt. For. and Range Exp. Stn., Misc. Publ. 18, 12 p., illus.

107. U.S. Forest Service
1960. Forest insect conditions in the Intermountain and northern Rocky Mountain States during 1959. USDA For. Serv., Intermt. For. and Range Exp. Stn. Misc. Publ. 23, 12 p., illus.

108. U.S. Forest Service
1962. Forest insect conditions in the Northern Region, 1961. USDA For. Serv. [North. Reg.], Missoula, Mont., 7 p., illus.

109. U.S. Forest Service
1963. Forest insect conditions in the Northern Region, 1962. USDA For. Serv. [North. Reg.], Missoula, Mont., 12 p., illus.

110. U.S. Forest Service
[1963]. Forest protection against the spruce budworm - 1963. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 12 p., illus.

111. U.S. Forest Service
[1964]. Forest protection against the spruce budworm, 1963. USDA For. Serv., Intermt. Reg. and Intermt. For. and Range Exp. Stn. [Ogden, Utah], 12 p.

112. U.S. Forest Service
1965. Evaluation of chemicals for control of forest insects. USDA For. Serv., Pac. Southwest For. and Range Exp. Stn., Berkeley, Calif., 8 p.
113. U.S. Forest Service
[n.d.] Spruce budworm, No. 1 insect enemy of Douglas-fir in Montana. USDA For. Serv., North. Reg., Missoula, Mont., 7 p., illus.
114. Washburn, Richard I.
1956. Electronic recorder as aid in aerial insect surveys. USDA For. Serv., Intermt. For. and Range Exp. Stn. Res. Note 31, 3 p.
115. Washington State University
1971. Chemical insect control handbook. Wash. State Univ., Coll. Agric., Coop. Ext. Serv., Pullman, 329 p.
116. Whiteside, J. M., and V. M. Carolin, Jr.
1961. Spruce budworm in the western United States. USDA For. Serv., For. Pest Leafl. 53, 8 p., illus.
117. Wilkes, A., H. C. Coppel, and W. G. Mathers
1948. Notes on the insect parasites of the spruce budworm *Choristoneura fumiferana* (Clem.) in British Columbia. Can. Entomol. 80:138-155.
118. Williams, Carroll B., Jr., and Gerald S. Walton
1968. Effects of Naled and Zectran on the budworm *Choristoneura occidentalis* and associated insects in Montana. J. Econ. Entomol. 61(3):784-787.
119. Williams, Carroll Burns, Jr.
1963. The impact of defoliation by the spruce budworm on the growth, specific gravity, and competitive abilities of three tree species in northeastern Oregon. Ph.D. Diss., Univ. Mich., 242 p. Univ. Microfilms, Ann Arbor. (Diss. Abstr. 24:2208-2209.)
120. Williams, Carroll B., Jr.
1966. Differential effects of the 1944-56 spruce budworm outbreak in eastern Oregon. USDA For. Serv. Res. Pap. PNW-33, 16 p.
121. Williams, Carroll B., Jr.
1967. Spruce budworm damage symptoms related to radial growth of grand fir, Douglas-fir, and Engelmann spruce. For. Sci. 13(3):274-285.

UNPUBLISHED REFERENCES

U1. Anonymous
1952. Experimental airplane spraying for spruce budworm control, 1951. USDA Bur. Entomol. and Plant Quar.; Quebec [Can.], Dep. Lands and For.; and State of Maine; For. Serv. [Beltsville, Md.]. 28 p., illus.

U2. Anonymous
1953. An experiment with a TMB airplane on the effect of flight altitude on spruce budworm control, 1952 season. USDA Bur. Entomol. and Plant Quar. [Beltsville, Md.], 26 p., illus.

U3. Anonymous
1955. Forest insect situation on forest lands of all ownerships within Montana, north Idaho, and northwest Washington, October 1955. Mont. State Forester and USDA For. Serv., North. Reg. and Intermt. For. and Range Exp. Stn. [Missoula, Mont.], 17 p.

U4. Anonymous
1956. Forest insect situation on forest lands of all ownerships within Montana, north Idaho, and northeast Washington. Mont. State Forester and USDA For. Serv., North. Reg. and Intermt. For. and Range Exp. Stn. [Missoula, Mont.], 15 p.

U5. Anonymous
1956. Montana's spruce budworm problem in brief. Mont. State Forester and USDA For. Serv. [Northern Reg., Missoula, Mont.], 2 p.

U6. Anonymous
1965. Report of residue analysis. USDA Entomol. Res. Div., Pestic. Chem. Res. Branch, Yakima, Wash. Rep. PCY-65-11, 14 p.

U7. Anonymous
1967. Results, spruce budworm mortality. [Zectran test, Sawtooth Natl. For., Idaho, 1967.] [USDA For. Serv., Pac. Southwest For. and Range Exp. Stn., Berkeley, Calif.], 2 p.

U8. Baggley, George F., and Maynard Barrows
1934. Yellowstone National Park [Idaho, Montana, and Wyoming], annual insect report for 1934. U.S. Dep. Inter., Natl. Park Serv., Yellowstone Natl. Park, Wyo., 8 p., illus.

U9. Baggley, George F., and Fred T. Johnston
1930. Annual forest insect report for Yellowstone National Park [Idaho, Montana, and Wyoming] [Season of 1930]. U.S. Dep. Inter., Natl. Park Serv., Yellowstone Natl. Park, Wyo., 10 p.

U10. Baggley, George F., and Fred T. Johnston
1933. Annual forest insect report, Yellowstone National Park [Idaho, Montana, and Wyoming], 1933. U.S. Dep. Inter., Natl. Park Serv., Yellowstone Natl. Park, Wyo., 6 p.

U11. Baker, Bruce H.
[1968]. Biological evaluation of forest insect problems on the Targhee National Forest [Idaho] during 1968. USDA For. Serv., Intermt. Reg., Ogden, Utah, 9 p.

U12. Baker, Bruce H.
1969. Biological evaluation of forest insect conditions on the Teton National Forest and in Grand Teton National Park [Wyoming] during 1968. USDA For. Serv., Intermt. Reg., Ogden, Utah, 5 p.

U13. Balch, R. E.
1929. Report on some insect infestations within holdings of the Clearwater Timber Company [Idaho]. USDA Bur. Entomol., Coeur d'Alene, Idaho, 14 p.

U14. Balch, R. E.
[1929]. Spruce budworm attacks lodgepole. USDA Bur. Entomol. [Coeur d'Alene, Idaho], 3 p.

U15. Balch, R. E.
1930. The spruce budworm epidemic on lodgepole in Wyoming. USDA Bur. Entomol., Coeur d'Alene, Idaho, 33 p., illus.

U16. Bicknell, A. T.
[1929]. Spruce budworm in lodgepole pine. [U.S. Dep. Inter., Natl. Park Serv., Yellowstone Natl. Park, Wyo.], 4 p

U17. Blackmer, F. H.
[1953]. Spruce budworm spray project, Helena [and] Deerlodge [National Forests, Montana], 1953. USDA For. Serv., Helena Natl. For., Helena, Mont.], 9 p., illus.

U18. Buckhorn, W. J., and D. W. Berry
1953. The La Grande experimental spruce budworm control project, season of 1951. USDA Bur. Entomol. and Plant Quar. [Portland, Oreg.], 10 p., illus.

U19. Burke, H. E.
1926. Forest insect conditions in the Yellowstone National Park [Idaho, Montana, and Wyoming] during the season of 1925. USDA Bur. Entomol., Stanford Univ., Calif., 13 p., illus.

U20. Burke, H. E.
1927. Forest insect conditions in the Yellowstone National Park [Idaho, Montana, and Wyoming] during the season of 1926. USDA Bur. Entomol., Stanford Univ., Calif., 13 p., illus.

U21. Burke, H. E.
1928. Forest insect conditions in the Yellowstone National Park [Idaho, Montana, and Wyoming] during the season of 1927. USDA Bur. Entomol., Stanford Univ., Calif., 13 p., illus.

U22. Carolin, V. M.
1950. Studies of the biological control of the spruce budworm in Oregon--1950. USDA Bur. Entomol. and Plant Quar., New Haven, Conn.

U23. Carolin, V. M., and W. K. Coulter
1959. Research findings relative to the biological evaluation of spruce budworm infestations in Oregon. USDA For. Serv., Pac. Northwest For. and Range Exp. Stn., Portland, Oreg., 39 p.

U24. Cole, Walter E.
[1955]. The spruce budworm in southern Idaho, with special reference to surveys, August-September 1955 aerial and appraisal surveys. USDA For. Serv., Intermt. For. and Range Exp. Stn., Boise, Idaho, 11 p., illus.

U25. Cole, Walter E.
[1956]. Entomological aspects of the 1956 spruce budworm control project in southern Idaho. USDA For. Serv., Intermt. For. and Range Exp. Stn., 10 p., illus.

U26. Cole, Walter E.
[1956]. Spruce budworm in southern Idaho, appraisal survey, August-September 1956. USDA For. Serv., Intermt. For. and Range Exp. Stn., [Boise, Idaho], 11 p., illus.

U27. Cole, Walter E.
[1957]. Entomological aspects of the 1957 spruce budworm control project in southern Idaho. USDA For. Serv., Intermt. For. and Range Exp. Stn., 6 p., illus.

U28. Cole, Walter E.
[1957]. Spruce budworm in southern Idaho, appraisal-aerial survey, August-September 1957. USDA For. Serv., Intermt. For. and Range Exp. Stn., Boise, Idaho, 9 p., illus.

U29. Cole, Walter E.
[1958]. Spruce budworm situation in southern Idaho, 1958. USDA For. Serv., Intermt. For. and Range Exp. Stn., Boise, Idaho, 8 p., illus.

U30. Cole, W. E., and W. E. Mineau
[1957]. Salmon National Forest [Idaho], annual aerial survey, August 1957. USDA For. Serv., Intermt. For. and Range Exp. Stn., Boise, Idaho, 4 p., illus.

U31. Cole, W. E., and W. E. Mineau
[1958]. Payette National Forest [Idaho], annual aerial survey, August-September 1958. USDA For. Serv., Intermt. For. and Range Exp. Stn., Boise, Idaho, 4 p., illus.

U32. Cole, W. E., and W. E. Mineau
[1958]. Salmon National Forest [Idaho], annual aerial survey, August 1958. USDA For. Serv., Intermt. For. and Range Exp. Stn., Boise, Idaho, 4 p., illus.

U33. Cole, W. E., and W. E. Mineau
[1958]. Sawtooth National Forest [Idaho], annual aerial survey, August 1958. USDA For. Serv., Intermt. For. and Range Exp. Stn., Boise, Idaho, 4 p., illus.

U34. Collis, R. T. H., and John Oblanas
1967. Lidar observations of forest spraying operations, final report. Stanford Res. Inst., Menlo Park, Calif., 63 p., illus.

U35. Corley, Donald R., Ted C. Bjornn, and William C. Webb
1965. The effects of a DDT spray application on the aquatic organisms in Hughes Creek, Idaho. 48 p., *In*: Casebeer, Robert L., Monitoring the 1964 spruce budworm aerial spray project. USDA For. Serv., Intermt. Reg., Ogden, Utah, 133 p.

U36. Davis, J. M., D. A. Isler, B. Maksymiuk, and T. T. Terrell
1957. The effect of spraying height on spruce budworm control using a B-18 airplane, 1956 season. USDA For. Serv., For. Insect Lab. [Beltsville, Md.], and Intermt. For. and Range Exp. Stn. [Ogden, Utah], Spec. Rep. BV 57-1, 18 p.

U37. Davis, J. M., B. Maksymiuk, D. A. Isler, and T. T. Terrell
1958. The effect of seven-hundred-fifty-foot spraying height on spruce budworm control using a B-18 airplane. USDA For. Serv., For. Insect Lab. [Beltsville, Md.] and Intermt. For. and Range Exp. Stn. [Ogden, Utah], Spec. Rep. BV 58-2, 15 p.

U38. Denton, Robert E.
1950. Spruce budworm infestations in the Clearwater, Nezperce, and Payette National Forests, Idaho, season of 1950. USDA Bur. Entomol. and Plant Quar., Coeur d'Alene, Idaho, 5 p.

U39. Denton, Robert E.
1950. The spruce budworm infestation in the Flathead National Forest: South Fork Primitive Area, Montana, season of 1950. USDA Bur. Entomol. and Plant Quar., Coeur d'Alene, Idaho, 5 p., illus.

U40. Denton, Robert E.
1950. The spruce budworm aerial survey, Flathead National Forest: South Fork Primitive Area [Montana], season of 1950. 3 p., *In*: The spruce budworm infestation in the Flathead National Forest: South Fork Primitive Area, season of 1950. USDA Bur. Entomol. and Plant Quar., Coeur d'Alene, Idaho.

U41. Denton, Robert E.
1950. The spruce budworm infestation in the Lolo National Forest: Powell Ranger District [Idaho], season of 1950. USDA Bur. Entomol. and Plant Quar., Coeur d'Alene, Idaho, 4 p.

U42. Denton, Robert E.
1951. Investigations of the spruce budworm and its control: some applications of the results of forced emergence from hibernacula. Progress report, season of 1950. U.S. Bur. Entomol. and Plant Quar., Coeur d'Alene, Idaho, May 7. 8 p., illus.

U43. Denton, Robert E.
1952. Studies of methods of improving the accuracy and general efficiency of spruce budworm surveys: 1951 progress report. USDA Bur. Entomol. and Plant Quar., Coeur d'Alene, Idaho, April, 9 p. illus.

U44. Denton, Robert E.
1952. Spruce budworm conditions in the northern Rocky Mountains, 1951, reconnaissance surveys. USDA Bur. Entomol. and Plant Quar., Coeur d'Alene, Idaho, 19 p.

U45. Denton, Robert E.
1952. Spruce budworm conditions in the northern Rocky Mountains, 1952. USDA Bur. Entomol. and Plant Quar., Coeur d'Alene, Idaho, 10 p.

U46. Denton, Robert E.
1953. Studies of methods of improving the accuracy and general efficiency of spruce budworm surveys 1952 progress report. USDA Bur. Entomol. and Plant Quar., Coeur d'Alene, Idaho, 7 p., illus.

U47. Denton, Robert E.
1953. Summary of the more important defoliator conditions in the northern Rocky Mountains in 1953. USDA Bur. Entomol. and Plant Quar., Coeur d'Alene, Idaho, 3 p.

U48. Denton, Robert E.
[1954]. Entomological aspects of the 1953 spruce budworm control projects in the northern Rocky Mountains, progress report 1954. USDA For. Serv., Intermt. For. and Range Exp. Stn., Missoula, Mont., 8 p.

U49. Denton, Robert E.
1954. Forest defoliator conditions in the northern Rocky Mountains--1953. USDA For. Serv., Intermt. For. and Range Exp. Stn., Coeur d'Alene, Idaho, 15 p.

U50. Denton, Robert E.
1959. Unpublished reports in the files of the Missoula Forest Insect Laboratory (1915-1959). USDA For. Serv., Intermt. For. and Range Exp. Stn., Missoula, Mont., 59 p.

U51. Denton, Robert E.
1960. Experimental control of the spruce budworm by partial-unit spraying. USDA For. Serv., Intermt. For. and Range Exp. Stn., Missoula, Mont., 10 p., illus.

U52. Denton, Robert E.
1960. Experimental tests of *Bacillus thuringiensis* Berliner against the spruce budworm. USDA For. Serv., Intermt. For. and Range Exp. Stn., Missoula, Mont., 5 p.

U53. Dewey, Jerald E.
1969. Results of a Douglas-fir cone and seed study in Montana and Yellowstone National Park, 1968. USDA For. Serv., Missoula, Mont., 9 p., illus.

U54. Dewey, Jerald E.
1972. A three year evaluation of Douglas-fir cone and seed insects in Montana and Yellowstone National Park [Wyoming]. USDA For. Serv., Missoula, Mont., 19 p., illus.

U55. Dewey, Jerald E., and Frederick W. Honing
1968. A study of insects attacking Douglas-fir cones in eastern Montana and Yellowstone National Park [Wyoming]. USDA For. Serv., North. Reg., Missoula, Mont., 15 p., illus.

U56. Dodge, Harold R.
1960. Spruce budworm parasite investigations in Montana; a progress report. USDA For. Serv., Intermt. For. and Range Exp. Stn., Missoula, Mont., 20 p.

U57. Eaton, C. B., H. A. Jaynes, and J. M. Muiry
1948. Experiments with airplane applications of DDT for spruce budworm control, 1947 season. USDA Bur. Entomol. and Plant Quar., Beltsville, Md., 26 p., illus.

U58. Evenden, James C.
[n.d.]. Information concerning tree killing insects of the northern Rocky Mountain region. USDA Bur. Entomol. and Plant Quar., Coeur d'Alene, Idaho, 19 p., illus.

U59. Evenden, James C.
1922 Forest insect conditions, Payette and Little Salmon River watersheds, Idaho, September 1922. USDA Bur. Entomol., Coeur d'Alene, Idaho, 20 p., illus.

U60. Evenden, James C.
[1922]. Spruce budworm in northern Idaho. USDA Bur. Entomol., Coeur d'Alene, Idaho, 12 p., illus.

U61. Evenden, James C.
1923. Defoliation of timber stands within the Yellowstone National Park [Idaho, Montana, and Wyoming], 1923. USDA Bur. Entomol., Coeur d'Alene, Idaho, 12 p., illus.

U62. Evenden, James C.
1924. Forest insect problems of the Yellowstone National Park [Idaho, Montana, and Wyoming]. USDA Bur. Entomol., Coeur d'Alene, Idaho, 10 p., illus.

U63. Evenden, James C.
1929. Annual forest insect status report, season of 1928. USDA Bur. Entomol., Couer d'Alene, Idaho, 10 p.

U64. Evenden, James C.
1929 Forest insect conditions in the Yellowstone National Park [Idaho, Montana, and Wyoming], season of 1928. USDA Bur. Entomol., Coeur d'Alene, Idaho, 16 p.

U65. Evenden, James C.
1930. Annual forest insect status report, season of 1929. USDA Bur. Entomol., Coeur d'Alene, Idaho, 16 p.

U66. Evenden, James C.
1930. Experimental spraying for control of the spruce budworm in the Cody Canyon, Shoshone National Forest [Wyoming]. USDA Bur. Entomol., Coeur d'Alene, Idaho, 5 p., illus.

U67. Evenden, James C.
1930. Forest insect conditions in Yellowstone National Park [Idaho, Montana, and Wyoming], season of 1929. USDA Bur. Entomol., Coeur d'Alene, Idaho, 11 p., illus.

U68. Evenden, James C.
1931. Annual forest insect status report, season of 1930. USDA Bur. Entomol., Coeur d'Alene, Idaho, 22 p.

U69. Evenden, James C.
1931. Forest insect conditions in the Yellowstone National Park [Idaho, Montana, and Wyoming], season 1930. USDA Bur. Entomol., Coeur d'Alene, Idaho, 9 p.

U70. Evenden, James C.
1931. Experimental spraying for the control of the spruce budworm in the Cody Canyon, Shoshone National Forest [Wyoming], 1930. USDA Bur. Entomol., Coeur d'Alene, Idaho, 48 p., illus.

U71. Evenden, James C.
1932. Forest insect conditions in the Yellowstone National Park [Idaho, Montana, and Wyoming], season 1931. USDA Bur. Entomol., Coeur d'Alene, Idaho, 9 p.

U72. Evenden, James C.
1932. Annual forest insect status report, season of 1931. USDA Bur. Entomol., Coeur d'Alene, Idaho, 22 p.

U73. Evenden, James C.
1932. Experimental spraying for the control of the spruce budworm in the Cody Canyon, Shoshone National Forest [Wyoming] 1931. USDA Bur. Entomol., Coeur d'Alene, Idaho, 63 p., illus.

U74. Evenden, James C.
1933. Experimental spraying for the control of the spruce budworm in the Cody Canyon, Shoshone National Forest [Wyoming], 1932. USDA Bur. Entomol., Coeur d'Alene, Idaho, 63 p.

U75. Evenden, James C.
1933. Annual forest insect status report, season 1932. USDA Bur. Entomol., Coeur d'Alene, Idaho, 12 p.

U76. Evenden, James C.
1934. Annual forest insect status report, season of 1933. USDA Bur. Entomol., Coeur d'Alene, Idaho, 18 p.

U77. Evenden, James C.
1935. Annual forest insect status report, season of 1934. USDA Bur. Entomol., Coeur d'Alene, Idaho, 16 p.

U78. Evenden, James C.
1936. Annual forest insect status report, season of 1935. USDA Bur. Entomol., Coeur d'Alene, Idaho, 12 p.

U79. Evenden, James C.
1937. Annual forest insect status report, season of 1936. USDA Bur. Entomol., Coeur d'Alene, Idaho, 13 p.

U80. Evenden, James C.
1938. Annual forest insect status report, Region 1, 1937. USDA Bur. Entomol., Coeur d'Alene, Idaho, 16 p.

U81. Evenden, James C.
1939. Annual forest insect status report, Region 1, 1938. USDA Bur. Entomol., Coeur d'Alene, Idaho, 17 p.

U82. Evenden, James C.
[1940]. Annual forest insect status report, Idaho and Montana, 1939. USDA Bur. Entomol., Coeur d'Alene, Idaho, 19 p.

U83. Evenden, James C.
1941. Annual forest insect status report, Idaho and Montana, 1940. USDA Bur. Entomol., Coeur d'Alene, Idaho, 15 p.

U84. Evenden, James C.
1942. Annual forest insect status report, Idaho and Montana, 1941. USDA Bur. Entomol. and Plant Quar., Coeur d'Alene, Idaho, 14 p.

U85. Evenden, James C.
1943. Annual forest insect status report, Idaho and Montana, 1942. USDA Bur. Entomol. and Plant Quar., Coeur d'Alene, Idaho, 10 p.

U86. Evenden, James C.
1943. History of forest insect problems, Yellowstone National Park [Montana and Wyoming]. USDA Bur. Entomol. and Plant Quar., Coeur d'Alene, Idaho, 14 p.

U87. Evenden, James C.
1944. Annual forest insect status report, Idaho and Montana, year 1943. USDA Bur. Entomol. and Plant Quar., Coeur d'Alene, Idaho, 4 p.

U88. Evenden, James C.
1944. History of forest defoliations by forest insects, Region One. USDA Bur. Entomol. and Plant Quar., Coeur d'Alene, Idaho, 7 p.

U89. Evenden, James C.
1945. Annual forest insect status report, Idaho and Montana, 1944. USDA Bur. Entomol. and Plant Quar., Coeur d'Alene, Idaho, 8 p.

U90. Evenden, James C.
[1946]. Annual forest insect status report, Idaho and Montana, 1945. USDA Bur. Entomol. and Plant Quar., Coeur d'Alene, Idaho, 9 p.

U91. Evenden, James C.
[1949]. Annual forest insect status report, Idaho and Montana, 1948. USDA Bur. Entomol. and Plant Quar., Coeur d'Alene, Idaho, 9 p.

U92. Evenden, James C.
[1950]. Annual forest insect status report, Idaho and Montana, 1949. USDA Bur. Entomol. and Plant Quar., Coeur d'Alene, Idaho, 13 p.

U93. Evenden, James C.
1951. Forest insect conditions and entomological service activities, north Idaho and Montana, 1950. USDA Bur. Entomol. and Plant Quar., Coeur d'Alene, Idaho, 14 p.

U94. Evenden, James C.
1954. Preliminary statement, status of forest insect conditions, northern Idaho and Montana, September 1, 1954. USDA For. Serv. [Intermt. For. and Range Exp. Stn.], Coeur d'Alene, Idaho, 6 p.

U95. Evenden, James C., and E. J. Yost
[1948]. Tussock moth control, north Idaho, 1947. USDA For. Serv., Bur. Entomol. and Plant Quar. [Missoula, Mont.], 51 p., illus.

U96. Fellin, David G.
1959. Biological evaluation of 1958 spruce spider mite infestations in Montana. USDA For. Serv., Intermt. For. and Range Exp. Stn., Missoula, Mont., 7 p., illus.

U97. Fellin, David G., Robert E. Denton, and Philip C. Johnson
1959. Biological guideline for the experimental control of the spruce budworm, Bitterroot National Forest, Montana, 1959. USDA For. Serv., Intermt. For. and Range Exp. Stn. and North. Reg., Missoula, Mont., 6 p., illus.

U98. Franc, G. C., P. W. Underwood, and J. E. Dewey
1972. A western spruce budworm impact survey on the Clearwater National Forest [Idaho]. USDA For. Serv., Missoula, Mont., Rep. I-72-4, 5 p.

U99. Furniss, Malcolm M.
1955. An appraisal survey of spruce budworm damage on parts of the Boise and Payette National Forests in southern Idaho, November 1954. USDA For. Serv., Intermt. For. and Range Exp. Stn., 11 p., illus.

U100. Furniss, Malcolm M.
1955. Plan for the technical direction of the 1955 spruce budworm control project in southern Idaho. [USDA For. Serv.], Intermt. For. and Range Exp. Stn., 13 p., illus.

U101. Gibson, Archie L.
1949. Forest defoliator conditions in a portion of western Idaho, 1949. USDA Bur. Entomol. and Plant Quar., Coeur d'Alene, Idaho, 2 p.

U102. Gibson, Archie L.
1953. Spruce budworm control, Nezperce National Forest, Riggins [Ranger] District, [Idaho], 1953. USDA Bur. Entomol. and Plant Quar., Coeur d'Alene, Idaho, 4 p.

U103. Graham, R. J., and David O. Scott
1958. Effects of forest insect spraying on trout and aquatic insects in some Montana streams. U.S. Dep. Inter., Fish and Wildl. Serv.; Mont. Fish and Game Dep.; U.S. Dep. Agric., For. Serv., North. Reg. [Missoula, Mont.], 50 p., illus.

U104. Honing, Frederick W.
1968. Spruce budworm Zectran pilot control test, Bitterroot National Forest [Montana], 1966. USDA For. Serv., North. Reg., Missoula, Mont., 12 p., illus.

U105. Isler, D. A., and Bohdan Maksymiuk
1958. Spray atomization and deposit pattern tests of airplanes used for spruce budworm control. USDA For. Serv., For. Insect Lab. [Beltsville, Md.], Spec. Rep. BV 58-3, 44 p.

U106. James, Corland L.
1952. Report on the spruce budworm control project, east fork of the Bitterroot River [Montana]. USDA For. Serv., Bitterroot Natl. For., Hamilton, Mont., 6 p., illus.

U107. Johnson, Philip C.
1949. Forest insect conditions, Helena National Forest, Montana, season of 1948. USDA Bur. Entomol. and Plant Quar., Coeur d'Alene, Idaho, 10 p.

U108. Johnson, Philip C.
1949. Spruce budworm detection survey; Helena, Gallatin, and Deerlodge National Forests, Montana, October 1949. USDA Bur. Entomol. and Plant Quar., Coeur d'Alene, Idaho, 9 p.

U109. Johnson, Philip C.
1950. Forest insect conditions, Boulder Ranger District, Deerlodge National Forest, Montana, season of 1950. USDA Bur. Entomol. and Plant Quar., Coeur d'Alene, Idaho, 3 p.

U110. Johnson, Philip C.
1950. Forest insect conditions, Glacier National Park, Montana, season of 1950. USDA Bur. Entomol. and Plant Quar., Coeur d'Alene, Idaho, 5 p., illus.

U111. Johnson, Philip C.
1950. Status of spruce budworm infestations, Helena National Forest, Montana, season of 1950. USDA Bur. Entomol. and Plant Quar., Coeur d'Alene, Idaho, 4 p.

U112. Johnson, Philip C.
1951. Forest insect conditions, Glacier National Park, Montana, season of 1951. Bur. Entomol. and Plant Quar., Coeur d'Alene, Idaho, 4 p.

U113. Johnson, Philip C.
1952. Entomological phases of the 1952 spruce budworm control project on the Bitterroot National Forest, Montana. USDA Bur. Entomol. and Plant Quar., Coeur d'Alene, Idaho, 11 p.

U114. Johnson, Philip C.
1952. Forest insect conditions in the northern Rocky Mountains, 1951. USDA Bur. Entomol. and Plant Quar., Coeur d'Alene, Idaho, 38 p.

U115. Johnson, Philip C.
1955. Pertinent information about the spruce budworm in the northern Rocky Mountains. USDA For. Serv., Intermt. For. and Range Exp. Stn., Missoula, Mont., 4 p.

U116. Johnson, Philip C.
1955. Plans for the technical direction of the 1955 spruce budworm control project in western Montana and northern Idaho. USDA For. Serv., Intermt. For. and Range Exp. Stn., Missoula, Mont., 11 p.

U117. Johnson, Philip C.
1957. The 1957 spruce mite infestations in Montana. USDA For. Serv., Intermt. For. and Range Exp. Stn., Missoula, Mont., 15 p., illus.

U118. Johnson, Philip C.
1957. Spruce budworm infestation in Yellowstone National Park [Montana and Wyoming], 1956. USDA For. Serv., Intermt. For. and Range Exp. Stn., Missoula, Mont., 4 p.

U119. Johnson, Philip C.
1958. Biological guideline for the experimental control of the spruce budworm and the spruce spider mite, Helena National Forest, Montana, 1958. USDA For. Serv., Intermt. For. and Range Exp. Stn., Missoula, Mont., 22 p., illus.

U120. Keen, F. P., and James C. Evenden
1929. The role of forest insects in respect to timber damage in the smelter fume area near Northport, Washington. USDA Bur. Entomol. [Stanford Univ., Calif.], 32 p., illus.

U121. Klein, William H.
1965. Insect conditions on the Targhee National Forest, 1965. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 6 p.

U122. Klein, William H.
1965. Forest insect conditions on the Salmon National Forest, 1965. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 3 p.

U123. Klein, William H.
1965. Forest insect conditions on the Fishlake National Forest, 1965. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 3 p.

U124. Klein, William H.
1965. Forest insect conditions on the Bridger National Forest, 1965. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 5 p.

U125. Klein, William H.
1966. Forest insect conditions on the Targhee National Forest, 1966. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 7 p.

U126. Klein, William H.
1966. Forest insect conditions on the Salmon National Forest, 1966. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 5 p.

U127. Klein, William H.
1966. Forest insect conditions on the Fishlake National Forest, 1966. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 3 p.

U128. Klein, William H.
1966. Forest insect conditions on the Bridger National Forest, 1966. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 4 p.

U129. Klein, William H.
1967. Forest insect conditions on the Teton National Forest and in Grand Teton National Park, 1967. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 6 p.

U130. Klein, William H.
1967. Forest insect conditions on the Targhee National Forest, 1967. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 7 p.

U131. Klein, William H.
1967. Forest insect conditions on the Salmon National Forest, 1967. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 3 p., Map.

U132. Klein, William H.
1967. Forest insect conditions on the Fishlake National Forest, 1967. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 5 p., Map.

U133. Klein, William H.
1967. Forest insect conditions on the Caribou National Forest, 1967. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 4 p.

U134. Klein, William H.
1967. Forest insect conditions on the Bridger National Forest, 1967. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 9 p.

U135. Klein, William H.
1968. Biological evaluation of forest insect conditions on the Salmon National Forest during 1968. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 4 p.

U136. Klein, William H.
1969. Forest insect conditions on the Teton National Forest and in Grand Teton National Park, 1969. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 11 p., illus.

U137. Klein, William H.
1969. Biological evaluation of forest insect conditions on the Salmon National Forest during 1969. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 3 p.

U138. Klein, William H.
1969. Forest insect conditions on the Bridger National Forest, 1969. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 20 p., illus.

U139. Klein, William H.
1969. Biological evaluation of forest insect conditions on the Ashley National Forest, 1969. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 3 p.

U140. Klein, William H.
1970. Forest insect conditions on the Bridger National Forest, 1970. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 15 p., illus.

U141. Klein, William H.
1970. Biological evaluation of forest insect problems on the Ashley National Forest, 1970. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 8 p., illus.

U142. Klein, William H.
1971. Forest insect conditions on the Bridger National Forest, 1971. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 9 p. maps.

U143. Klein, William H., and Jerry A. E. Knopf
1965. Biological evaluations of spruce budworm infestations in 1965 on the Boise, Bridger, Challis, Fishlake, Payette, Salmon, Sawtooth, and Targhee National Forests in Idaho, Wyoming, and Utah. USDA For. Serv., Intermt. Reg., Ogden, Utah, 17 p.

U144. Klein, William H., and Jerry A. E. Knopf
1966. Biological evaluations of spruce budworm infestations in 1966 on the Boise, Bridger, Challis, Fishlake, Payette, Salmon, Sawtooth, and Targhee National Forests in Idaho, Wyoming, and Utah. USDA For. Serv., Intermt. Reg., Ogden, Utah, 20 p.

U145. Knopf, Jerry A. E.
1965. Status of forest insects on the Sawtooth National Forest - 1965. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 5 p.

U146. Knopf, Jerry A. E.
1965. Status of forest insects on the Payette National Forest - 1965. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 4 p.

U147. Knopf, Jerry A. E.
1965. Status of forest insects on the Challis National Forest - 1965. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 3 p.

U148. Knopf, Jerry A. E.
1965. The status of forest insects on the Boise National Forest, 1965. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 6 p.

U149. Knopf, Jerry A. E.
1966. Forest insect conditions on the Sawtooth National Forest, 1966. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 5 p.

U150. Knopf, Jerry A. E.
1966. Forest insect conditions on the Payette National Forest, 1966. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 4 p.

U151. Knopf, Jerry A. E.
1966. Forest insect conditions on the Challis National Forest, 1966. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 3 p.

U152. Knopf, Jerry A. E.
1966. Forest insect conditions on the Boise National Forest, 1966. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 4 p.

U153. Knopf, Jerry A. E.
1967. Forest insect conditions on the Sawtooth National Forest, 1967. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 5 p.

U154. Knopf, Jerry A. E.
1967. Forest insect conditions on the Challis National Forest, 1967. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 3 p.

U155. Knopf, Jerry A. E.
1967. Forest insect conditions on the Payette National Forest, 1967. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 5 p.

U156. Knopf, Jerry A. E.
1967. Forest insect conditions on the Boise National Forest, 1967. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 4 p.

U157. Knopf, Jerry A. E.
1968. Biological evaluation of forest insect conditions on the Sawtooth National Forest during 1968. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 6 p.

U158. Knopf, Jerry A. E.
1968. Biological evaluation of forest insect conditions on the Payette National Forest during 1968. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 5 p.

U159. Knopf, Jerry A. E.
1968. Biological evaluation of forest insect conditions on the Challis National Forest during 1968. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 3 p.

U160. Knopf, Jerry A. E.
1968. Biological evaluation of forest insect conditions on the Boise National Forest during 1968. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 6 p.

U161. Knopf, Jerry A. E.
1969. Forest insect conditions on the Sawtooth National Forest, 1969. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 9 p.

U162. Knopf, Jerry A. E.
1969. Forest insect conditions on the Payette National Forest - 1969. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 10 p.

U163. Knopf, Jerry A. E.
1969. Biological evaluation of forest insect conditions on the Challis National Forest, 1969. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 6 p.

U164. Knopf, Jerry A. E.
1969. Forest insect conditions on the Boise National Forest - 1969. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 8 p.

U165. Knopf, Jerry A. E.
1970. Biological evaluation of forest insect conditions on the Payette National Forest during 1970. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 10 p.

U166. Knopf, Jerry A. E.
1970. Biological evaluation of forest insect conditions on the Challis National Forest during 1970. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 10 p.

U167. Knopf, Jerry A. E.
1970. Biological evaluation of forest insect conditions on the Boise National Forest during 1970. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 10 p.

U168. Knopf, Jerry A. E.
1971. Forest insect condtions on the Payette National Forest - 1971. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 10 p.

U169. Knopf, Jerry A. E.
1971. Forest insect conditions on the Boise National Forest - 1971. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 8 p.

U170. Koch, Elers, and James C. Evenden
1926. Annual insect control report, season 1925. USDA Bur. Entomol. [Coeur d'Alene, Idaho], 9 p.

U171. Koch, Elers, and James C. Evenden
1927. Annual insect control report, season 1926. USDA Bur. Entomol. [Coeur d'Alene, Idaho], 12 p.

U172. Koch, Elers, and James C. Evenden
1928. Annual forest insect report, season of 1927. USDA Bur. Entomol. [Coeur d'Alene, Idaho], 14 p.

U173. Kucera, Daniel R.
1963. Malathion test on spruce budworm at rate of one pound per acre, 1963. USDA For. Serv., North. Reg., Missoula, Mont., 7 p.

U174. Lindh, A. G.
1954. Spruce budworm meeting, proposed program of spruce budworm control. [USDA For. Serv., North. Reg., Missoula, Mont.], 7 p.

U175. Lister, C. K.
[1965]. Report on the use of Cygon as an experimental insecticide against the spruce budworm, 1964. USDA For. Serv. [Intermt. Reg.], Ogden, Utah, 13 p.

U176. Lister, C. K.
[1967]. Entomological aspects of the 1966 spruce budworm [malathion] pilot test. 3 p., in Solberg, Clifford T. [1967], Operational report, 1966 spruce budworm project, Salmon National Forest. [USDA For. Serv., Salmon Natl. For., Salmon, Idaho].

U177. Maksymiuk, Bohdan, John Neisess, Richard A. Waite, and Richard D. Orchard
1971. A field experiment in determining the effectiveness of fluorescent tracer Rhodamine for assessing spray deposit of registered Zectran formulation, Nezperce National Forest, Idaho, 1971. USDA For. Serv., Pac. Northwest For. and Range Exp. Stn., Corvallis, Oreg., Prog. Rep., 32 p.

U178. McComb, David
1956. Plans for the technical direction of the 1956 spruce budworm control project in western Montana and northern Idaho. USDA For. Serv., Intermt. For. and Range Exp. Stn., Missoula, Mont., 33 p., illus.
U179. McComb, David
1956. Spruce budworm ground appraisal survey procedures. USDA For. Serv., Intermt. For. and Range Exp. Stn., Missoula, Mont., 4 p.
U180. McComb, David, and Tom T. Terrell
1957. Status of the spruce budworm outbreak in the northern Rocky Mountain region, 1956. USDA For. Serv., Intermt. For. and Range Exp. Stn., Missoula, Mont., 8 p.
U181. McComb, David, and Tom T. Terrell
1958. Spruce budworm infestations, northern Rocky Mountain region, 1957. USDA For. Serv., Intermt. For. and Range Exp. Stn., Missoula, Mont., 9 p.
U182. McGregor, Mark D., and Jerald E. Dewey
1968. Operational plan, Zectran pilot test for spruce budworm control, Belmont Creek and Blacktail Mountain, Blackfoot River drainage, Montana, 1968. USDA For. Serv., North. Reg., Missoula, Mont., 11 p., illus.
U183. McGregor, Mark D., and Jerald E. Dewey
1969. Zectran pilot test to control spruce budworm in Belmont and Chamberlain Creeks, Blackfoot River drainage, Montana. USDA For. Serv., North. Reg., Missoula, Mont., 11 p.
U184. Miller, E. E.
1933. Notes on 1932 spraying in Cody Canyon [Shoshone National Forest, Wyoming], spruce budworm. USDA Bur. Entomol., Coeur d'Alene, Idaho, 8 p.
U185. Orr, L. W.
1951. Forest insect conditions in the Intermountain Region in 1950. USDA Bur. Entomol. and Plant Quar., Ogden, Utah, 9 p.
U186. Orr, L. W.
1952. Forest insect conditions in the Intermountain Region in 1951. USDA Bur. Entomol. and Plant Quar., Ogden, Utah, 11 p.
U187. Orr, L. W.
1952. Preliminary statement on forest insect infestations in 1952 in southern Idaho by the Forest Insect Laboratory, Ogden, Utah. [USDA Bur. Entomol. and Plant Quar.], Ogden, Utah, 3 p.
U188. Orr, L. W.
1954. Forest insect conditions in the Intermountain Region in 1953. USDA For. Serv., Intermt. For. and Range Exp. Stn., 5 p.
U189. Orr, L. W., Galen C. Trostle, and Marlin C. Galbraith
1968. Summary of official correspondence relating to spruce budworm infestations in Region Four prior to 1952. USDA For. Serv., Intermt. Reg., Ogden, Utah, 14 p.
U190. Park, Barry C.
1956. Facts about forest insect aerial spraying with DDT to control spruce budworm. USDA For. Serv. [North. Reg. and Intermt. For. and Range Exp. Stn.], Missoula, Mont., 14 p.
U191. Parker, Douglas L.
1968. Forest insect conditions on the Bridger National Forest, 1968. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 9 p.
U192. Parker, Douglas L.
1968. Forest insect conditions on the Ashley National Forest, 1968. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 4 p.
U193. Parker, Douglas L.
1969. Biological evaluation of forest insect conditions on the Targhee National Forest, 1969. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 11 p., illus.
U194. Patee, Robert K.
1966. Low volume application of malathion, Salmon National Forest [Idaho], Region 4, 1965. USDA For. Serv. [Intermt. Reg.], Ogden, Utah, 40 p., illus.

U195. Patee, Robert K.
1966. Spruce budworm damage survey by Division of Timber Management, Intermountain Region, U.S. Forest Service, 1965. [USDA For. Serv., Intermt. Reg., Ogden, Utah], 20 p.

U196. Rusk, H. W.
1965. Report on residue analysis [Cygon (dimethoate)]. [USDA] Agric. Res. Serv., Pestic. Chem. Branch, Yakima, Wash., Rep. PCY-65-11, 14 p.

U197. Rutledge, R. H.
1929. Summary of 1928 insect reports of Region Four. USDA For. Serv. [Intermt. Reg.], Ogden, Utah, 9 p.

U198. Rutledge, R. H.
1929. Summary of 1929 insect reports of Region Four. USDA For. Serv., Intermt. Reg., Ogden, Utah, 5 p.

U199. Rutledge, R. H.
1930. Summary of 1930 insect reports of Region Four. USDA For. Serv. [Intermt. Reg.], Ogden, Utah, 18 p.

U200. Rutledge, R. H., and J. C. Evenden
1931. Summary of 1931 insect reports of Region Four. USDA For. Serv., Intermt. Reg., Ogden, Utah, 13 p.

U201. Rutledge, R. H.
1935. Summary of 1935 insect reports of Region Four. USDA For. Serv., [Intermt. Reg.], Ogden, Utah, 17 p.

U202. Rutledge, R. H.
1937. Summary of 1937 insect reports of Region Four. USDA For. Serv. [Intermt. Reg.], Ogden, Utah, 10 p.

U203. Scott, David O.
1965. Malathion pilot test against the spruce budworm, 1965. USDA For. Serv. [North. Reg.], Missoula, Mont., 4 p.

U204. Scott, David O., and Daniel R. Kucera
1964. Low volume application of malathion for spruce budworm control, 1964. USDA For. Serv. [North. Reg.], Missoula, Mont., 5 p.

U205. Shaw, William H.
1955. Summary report of the Riggins Unit of the 1955 southwestern Idaho spruce budworm control project. [USDA For. Serv., Payette Natl. For., McCall, Idaho], 3 p.

U206. Solberg, Clifford T.
1965. Operational report, 1964 spruce budworm project located on the Salmon National Forest [Idaho]. USDA For. Serv., Intermt. Reg., Ogden, Utah, 75 p., illus.

U207. Solberg, Clifford T.
[1967]. Operational report, 1966 spruce budworm [malathion] project, Salmon National Forest [Idaho]. [USDA For. Serv., Salmon Natl. For., Salmon, Idaho], 4 p.

U208. South Idaho Forest Pest Action Council
1955. Forest insect conditions and proposed control program for 1955-1956, southern Idaho, Utah, Nevada, and western Wyoming. South Idaho For. Pest Action Counc. [Boise, Idaho], 7 p.

U209. Southern Idaho Forest Pest Action Council
1954. Proposed forest insect control program, Region 4, 1955. South. Idaho For. Pest Action Counc., Boise, Idaho, 4 p.

U210. Stipe, Lawrence E.
1971. Forest insect conditions on Teton National Forest and in Grand Teton National Park, 1971. USDA For. Serv., Intermt. Reg. [Ogden, Utah], 6 p., illus.

U211. Spencer, C. C.
1929. Spruce budworm control, Cody Canyon, Shoshone National Forest. USDA For. Serv., Memorandum, Shoshone Natl. For., Cody, Wyo., 3 p.

U212. Sutliff, C. B., and Philip C. Johnson
1955. Memorandum for spruce budworm control units and personnel. USDA For. Serv., North. Reg. [and Intermt. For. and Range Exp. Stn.], Missoula, Mont., 3 p.
U213. Taynton, Roger, and Robert K. Patee
1964. Operational plan, 1964 spruce budworm project, Division of Timber Management, Region Four. [USDA For. Serv., Intermt. Reg.], Ogden, Utah, 22 p., illus.
U214. Terrell, Tom T.
[1955]. Important forest insect oubreaks, northern Rocky Mountain region, 1955. USDA For. Serv., Intermt. For. and Range Exp. Stn., Missoula, Mont., 3 p.
U215. Terrell, Tom T.
1956. A guide for the aerial observation of insecticide spraying for spruce budworm control. USDA For. Serv., Intermt. For. and Range Exp. Stn., Missoula, Mont., 3 p.
U216. Terrell, Tom T.
1956. Spruce budworm infestation in Yellowstone National Park [Montana and Wyoming], 1955. USDA For. Serv., Intermt. For. and Range Exp. Stn., Missoula, Mont., 1 p.
U217. Terrell, Tom T.
1956. Spruce budworm infestations in the northern Rocky Mountain region, 1955. USDA For. Serv., Intermt. For. and Range Exp. Stn., Missoula, Mont., 7 p..
U218. Terrell, Tom T.
1957. Spruce budworm population densities in the northern Rocky Mountain region, 1957. USDA For. Serv., Intermt. For. and Range Exp. Stn., Missoula, Mont., 22 p.
U219. Terrell, Tom T.
1958. Survey of overwintering spruce budworm larval population, Helena National Forest [Montana] and Yellowstone National Park [Montana and Wyoming], 1958. USDA For. Serv., Intermt. For. and Range Exp. Stn., Missoula, Mont., 3 p.
U220. Terrell, Tom T.
1959. Forest insect conditions in the northern Rocky Mountain region, 1958. USDA For. Serv., Intermt. For. and Range Exp. Stn., Missoula, Mont., 6 p.
U221. Terrell, Tom T.
1960. Spruce budworm infestations in sprayed and unsprayed areas in the northern Rocky Mountain region, 1959. USDA For. Serv., Intermt. For. and Range Exp. Stn., Missoula, Mont., 5 p.
U222. Terrell, Tom T.
1960. Survival of spruce budworm larvae in unseasonal low temperatures in Montana in 1960. USDA For. Serv., Intermt. For. and Range Exp. Stn., Missoula, Mont., 2 p.
U223. Terrell, Tom T.
1961. Biological evaluation of spruce budworm infestations in the northern Rocky Mountain region in 1960. USDA For. Serv., Intermt. For. and Range Exp. Stn., Missoula, Mont., 12 p.
U224. Terrell, Tom T.
1961. Techniques of spruce budworm surveys in the northern Rocky Mountain region, 1960 progress report. USDA For. Serv., Intermt. For. and Range Exp. Stn., Missoula, Mont., 13 p., illus.
U225. Terrell, Tom T.
1962. Biological evaluations of spruce budworm infestations in controlled areas and proposed control areas in the Northern Region, 1962. USDA For. Serv., North. Reg., Missoula, Mont., 14 p.
U226. Terrell, T. T.
1962. Spruce budworm infestations in the Northern Region, 1961. USDA For. Serv., North. Reg., Missoula, Mont., 9 p.

U227. Terrell, T. T.
1963. Results of pilot test of phosphamidon against spruce budworm in Montana, 1962. USDA For. Serv. [North. Reg.], Missoula, Mont., 14 p., illus.

U228. Terrell, T. T.
1963. Spruce budworm infestations in the Northern Region, 1962. USDA For. Serv., North. Reg., Missoula, Mont., 7 p.

U229. Terrell, Tom T.
1964. Spruce budworm egg mass surveys in areas sprayed for control. USDA For. Serv., North. Reg., Missoula, Mont., 5 p.

U230. Terrell, Tom T.
1965. Biological evaluation of a spruce budworm infestation in the Bitterroot National Forest [Montana], 1965. USDA For. Serv., North. Reg., Missoula, Mont., 3 p.

U231. Terrell, Tom T.
1965. Biological evaluation of spruce budworm in the Tobacco Root and adjacent ranges, Montana, 1965. USDA For. Serv., North. Reg., Missoula, Mont., 4 p.

U232. Terrell, Tom T.
1965. Biological evaluation of spruce budworm infestation in the Mill Creek drainage, Gallatin National Forest [Montana], 1965. USDA For. Serv., North. Reg., Missoula, Mont. 3 p.

U233. Terrell, Tom T.
1962. Spruce budworm infestation in the Garnet Range, Montana, 1965. USDA For. Serv., North. Reg., Missoula, Mont., 3 p.

U234. Terrell, T. T.
1966. Spruce budworm infestation, Hick's Park campground, Gallatin National Forest [Montana], 1966. USDA For. Serv., North. Reg., Missoula, Mont., 3 p.

U235. Terrell, Tom T., Robert E. Denton, and David G. Fellin
1960. Biological evaluation of spruce budworm infestation in the northern Rocky Mountain region, 1959. USDA For. Serv., Intermt. For. and Range Exp. Stn., Missoula, Mont., 8 p.

U236. Terrell, Tom T., and William R. Driver
1967. Mill Creek spruce budworm control project, Gallatin National Forest [Montana], 1966. USDA For. Serv., North. Reg., and Gallatin Natl. For., Missoula, Mont., 5 p., illus.

U237. Terrell, Tom T., and David G. Fellin
1959. Spruce budworm infestations in the northern Rocky Mountain region, 1958. USDA For. Serv., Intermt. For. and Range Exp. Stn., Missoula, Mont., 13 p., illus.

U238. Terrell, Tom T., and David G. Fellin
1960. Study of techniques of spruce budworm surveys in the northern Rocky Mountain region, 1959 progress report. USDA For. Serv., Intermt. For. and Range Exp. Stn., Missoula, Mont., 14 p., illus.

U239. Terrell, Tom T., and Philip C. Johnson
1957. Preliminary summary of forest insect conditions in the northern Rocky Mountains, 1957. USDA For. Serv., Intermt. For. and Range Exp. Stn., 8 p.

U240. Terrell, Tom T., and Kenneth W. Keefe
1964. Spruce budworm infestations in the Northern Region, 1963. USDA For. Serv., North. Reg., Missoula, Mont., 6 p.

U241. Terrell, Tom T., and Kenneth W. Keefe
1965. Spruce budworm infestations in the Northern Region, 1964. USDA For. Serv., North. Reg., Missoula, Mont., 10 p., illus.

U242. Tunnock, Archibald, Jr.
1959. Summary of forest insect detection reports submitted to the Missoula Forest Insect Laboratory in 1958. USDA For. Serv., Intermt. For. and Range Exp. Stn., Missoula, Mont., 15 p.

U243. Tunnock, Archibald, Jr.
1960. Forest insect infestations in the northern Rocky Mountain region during 1960. USDA For. Serv., Intermt. For. and Range Exp. Stn., Missoula, Mont., 8 p.

U244. Tunnock, Archibald, Jr.
1960. Summary of forest insect field surveillance reports submitted to the Missoula Forest Insect Laboratory in 1959. USDA For. Serv., Intermt. For. and Range Exp. Stn., Missoula, Mont., 14 p.

U245. Tunnock, Scott
1961. Insect infestations reported during 1960 in forests of the northern Rocky Mountains. UUSDA For. Serv., Intermt. For. and Range Exp. Stn., Missoula, Mont., 17 p.

U246. Tunnock, Scott
1963. Forest insect conditions in the Northern Region during 1962. USDA For. Serv., North. Reg., Missoula, Mont., 7 p.

U247. Tunnock, Scott
1963. Forest insect conditions in the Northern Region during 1963. USDA For. Serv., North. Reg., Missoula, Mont., 7 p.

U248. Tunnock, Scott
1967. Forest insect conditions in the Northern Region, 1966. USDA For. Serv., North. Reg., Missoula, Mont., 13 p.

U249. U.S. Bureau of Entomology and Plant Quarantine
[1952]. Preliminary statement, forest insect infestations, northern Idaho and Montana. USDA Bur. Entomol. and Plant Quar., Coeur d'Alene, Idaho, 5 p.

U250. U. S. Forest Service
1930. Annual ranger district reports on insect conditions, Madison National Forest, Montana, 1925-1930. USDA For. Serv., Madison Natl. For., Sheridan, Mont., 35 p., illus.

U251. U.S. Forest Service
1933. Annual forest insect status reports, Weiser National Forest [Idaho], 1928-1933. USDA For. Serv., Weiser Natl. For., Weiser, Idaho, 20 p.

U252. U.S. Forest Service
1934. Annual forest insect status reports, Idaho National Forest, 1929-1934. USDA For. Serv., Idaho Natl. For., McCall, Idaho, 6 p.

U253. U.S. Forest Service
1934. Annual ranger district reports on insect conditions, Selway National Forest, Idaho, 1925-1934. USDA For. Serv., Selway Natl. For., Kooskia, Idaho, 91 p., illus.

U254. U.S. Forest Service
1937. Annual forest insect status reports, [1933-1937]. USDA For. Serv., Lemhi (Challis) Natl. For., Challis, Idaho, 8 p.

U255. U.S. Forest Service
1944. Annual ranger district reports on insect conditions, Absaroka National Forest, Montana, 1925-1944. USDA For. Serv., Absaroka Natl. For., Livingston, Mont., 132 p., illus.

U256. U.S. Forest Service
1953. Annual ranger district reports on insect conditions, Beaverhead National Forest, Montana, 1925-1953. USDA For. Serv., Beaverhead Natl. For., Dillon, Mont., 137 p.

U257. U.S. Forest Service
1953. Annual ranger district reports on insect conditions, Bitterroot National Forest, Montana, 1925-1953. USDA For. Serv., Bitterroot Natl. For., Hamilton, Mont. 171 p., illus.

U258. U.S. Forest Service
1953. Annual ranger district reports on insect conditions, Cabinet National Forest, Montana, 1925-1953. USDA For. Serv., Cabinet Natl. For., Thompson Falls, Mont., 218 p., illus.

U259. U.S. Forest Service
1953. Annual ranger district reports on insect conditions, Clearwater National Forest, Idaho, 1925-1953. USDA For. Serv., Clearwater Natl. For., Orofino, Idaho, 126 p., illus.

U260. U.S. Forest Service
1953. Annual ranger district reports on insect conditions, Coeur d'Alene National Forest, Idaho, 1925-1953. USDA For. Serv., Coeur d'Alene Natl. For., Coeur d'Alene, Idaho, 135 p., illus.

U261. U.S. Forest Service
1953. Annual ranger district reports on insect conditions, Colville National Forest, Washington, 1947-1953. USDA For. Serv., Colville Natl. For., Colville, Wash., 7 p., illus.

U262. U.S. Forest Service
1953. Annual ranger district reports on insect conditions, Custer National Forest, Montana, 1925-1953. USDA For. Serv., Custer Natl. For., Billings, Mont., 231 p.

U263. U.S. Forest Service
1953. Annual ranger district reports on insect conditions, Deerlodge National Forest, Montana, 1925-1953. USDA For. Serv., Deerlodge Natl. For., Butte, Mont., 182 p., illus.

U264. U.S. Forest Service
1953. Annual ranger district reports on insect conditions, Flathead National Forest, Montana, 1925-1953. USDA For. Serv., Flathead Natl. For., Kalispell, Mont., 302 p., illus.

U265. U.S. Forest Service
1953. Annual ranger district reports on insect conditions, Gallatin National Forest, Montana, 1925-1953. USDA For. Serv., Gallatin Natl. For., Bozeman, Mont., 217 p., illus.

U266. U.S. Forest Service
1953. Annual ranger district reports on insect conditions, Helena National Forest, Montana, 1925-1953. USDA For. Serv., Helena Natl. For., Helena, Mont., 175 p., illus.

U267. U.S.Forest Service
1953. Annual ranger district reports on insect conditions, Kaniksu National Forest, Idaho, 1925-1953. USDA For. Serv., Kaniksu Natl. For., Sandpoint, Idaho, 178 p., illus.

U268. U.S. Forest Service
1953. Annual ranger district reports on insect conditions, Kootenai National Forest, Montana, 1925-1953. USDA For. Serv., Kootenai Natl. For., Libby, Mont., 189 p., illus.

U269. U.S. Forest Service
1953. Annual ranger district reports on insect conditions, Lewis & Clark National Forest, Montana, 1925-1953. USDA For. Serv., Lewis & Clark Natl. For., Great Falls, Mont., 152 p., illus.

U270. U.S. Forest Service
1953. Annual ranger district reports on insect conditions, Lolo National Forest, Montana, 1925-1953. USDA For. Serv., Lolo Natl. For., Missoula, Mont., 238 p., illus.

U271. U.S. Forest Service
1953. Annual ranger district reports on insect conditions, Nezperce National Forest, Idaho, 1925-1953. USDA For. Serv., Nezperce Natl. For., Grangeville, Idaho, 261 p., illus.

U272. U.S. Forest Service
1953. Annual ranger district reports on insect conditions, St. Joe National Forest, Idaho, 1925-1953. USDA For. Serv., St. Joe Natl. For., St. Maries, Idaho, 208 p., illus.

U273. U.S. Forest Service
1953. Spruce budworm control plan for 1953 and 1954, Montana and northern Idaho. A task force representing timber industry and the U.S. Dep. Agric., For. Serv. [North. Reg.], and Bur. Entomol. and Plant Quar., Missoula, Mont., 12 p., illus.

U274. U.S. Forest Service
1954. 1955 proposed spruce budworm control project, Boise and Payette National Forests, southwest Idaho, R-4. [USDA For. Serv., Intermt. Reg.], Ogden, Utah, 6 p., illus.

U275. U.S. Forest Service
[1956]. 1956 spruce budworm control project, organization and operating plan for Montana and north Idaho. USDA For. Serv. [North. Reg., Missoula, Mont.], 16 p.

U276. U.S. Forest Service
[1956]. Spruce budworm information, Montana-north Idaho spray operation, 1956. USDA For. Serv. [North. Reg., Missoula, Mont.], and the State Forester[s] [of Mont. and Idaho], 5 p., illus.

U277. U.S. Forest Service
1956. Summary of insect conditions, northern Rocky Mountains, 1956. USDA For. Serv., Intermt. For. and Range Exp. Stn., 6 p.

U278. U.S. Forest Service
[1957]. Forest insect condition report, Intermountain and Northern Rocky Mountain States, as of November 1, 1957. [USDA For. Serv., Intermt. For. and Range Exp. Stn.], 12 p.

U279. U.S. Forest Service
[1957]. 1957 spruce budworm control project, organization and operating plan for Montana and north Idaho. USDA For. Serv. [North. Reg., Missoula, Mont.], 21 p., illus.

U280. U.S. Forest Service
[1958]. Insect conditions in the Intermountain Station territory, 1958. Preliminary report. USDA For. Serv., Intermt. For. and Range Exp. Stn., 15 p.

U281. U.S. Forest Service
1958. Analyses and reviews of spruce budworm control activities. USDA For. Serv. [Missoula, Mont.], 40 p.

U282. U.S. Forest Service
1960. Gallatin National Forest [Montana] aerial spray project for spruce budworm control, 1960. USDA For. Serv. [Northern Reg.], Missoula, Mont., 8 p., illus.

U283. U.S. Forest Service
1960. Infestation characteristics of some forest insect pests native to the northern Rocky Mountains. USDA For. Serv., Intermt. For. and Range Exp. Stn., Missoula, Mont., 15 p., illus.

U284. U.S. Forest Service
1962. Forest insect conditions in the Northern Region, 1961. USDA For. Serv., North. Reg., Missoula, Mont., 7 p., illus.

U285. U.S. Forest Service
[1963]. Northern Region aerial spray projects for spruce budworm control, 1963. USDA For. Serv. [North. Reg., Missoula, Mont.], 9 p.

U286. U.S. Forest Service
[1964]. Report on the use of Sevin as an experimental insecticide against the spruce budworm, 1963. [USDA] For. Serv., Ogden, Utah, 10 p.

U287. U.S. Forest Service
1965. Spruce budworm malathion test project, Monture and Rock Creek units [Lolo National Forest, Montana], 1964. USDA For. Serv. [North. Reg.], Missoula, Mont., 12 p.

U288. U.S. Forest Service
1967. Spruce budworm control in the Ruby-Greenhorn ranges, Montana, 1966. U.S. Dep. Inter., Bur. Land Manage., and U.S. Dep. Agric., For. Serv. [North. Reg.], Missoula, Mont., 22 p., illus.

U289. U.S. Forest Service
1968. Fact sheet, Zectran--for control of spruce budworm. USDA For. Serv., North. Reg., Missoula, Mont., 7 p.

U290. U.S. Forest Service
1969. Minutes, 1960 Zectran pilot test analysis, Northern Region. USDA For. Serv., Missoula, Mont., 18 p.

U291. Washburn, R. I.
[1961]. The status of spruce budworm infestations in Forest Service Region 4, November 1961. USDA For. Serv. [Intermt. Reg.], Ogden, Utah, 5 p., illus.

U292. Washburn, Richard I.
1963. Spruce budworm infestations, Forest Service Region 4, November 1963. USDA For. Serv. [Intermt. Reg.], Ogden, Utah, 16 p., illus.

U293. Washburn, Richard I.
1964. Spruce budworm infestations, Forest Service Region 4, November 1964. USDA For. Serv. [Intermt. Reg.], Ogden, Utah, 17 p., illus.

U294. Washburn, R. I., and D. B. Cahill.
[1962]. Spruce budworm infestations, Forest Service Region 4, November 1962. USDA For. Serv. [Intermt. Reg.], Ogden, Utah, 12 p., illus.

U295. Washburn, R. I., and W. E. Cole
1959. The status of defoliator infestations in Forest Service Region 4, November 1959. USDA For. Serv., Intermt. For. and Range Exp. Stn., Ogden, Utah, 12 p., illus.

U296. Washburn, R. I. and W. E. Cole
[1960]. The status of defoliator infestations in Forest Service Region 4, November 1960. USDA For. Serv., Intermt. For. and Range Exp. Stn., Ogden, Utah, 13 p., illus.

U297. White, W. W.
1925. Annual insect control report, season of 1924. USDA For. Serv., North. Reg., Missoula, Mont., 12 p.

U298. Whitt, Charles R.
1967. Aquatic surveillance report, spruce budworm project, Gallatin National Forest, 1966. *In*: Terrell, T. T., and William R. Driver, Mill Creek spruce budworm control project, Gallatin National Forest, 1966. USDA For. Serv., North. Reg. and Gallatin Natl. For., Missoula, Mont., 5 p., illus.

U299. Whitt, Charles R.
1967. Aquatic surveillance report, spruce budworm project, Beaverhead National Forest, 1966. *In*: U.S. Forest Service, Spruce budworm control in the Ruby-Greenhorn Ranges, Montana, 1966. USDA For. Serv., Missoula, Mont., 22 p., illus.

APPENDIX

(Tables 1-20)

Table 1.--*Earliest recorded outbreaks of the western spruce budworm in National Forests in the Northern and Intermountain Regions, USDA Forest Service, and in Yellowstone National Park, 1922-1934.*

State	National Forest or Park	Years reported[1]
	NORTHERN REGION	
Idaho	Bitterroot	1926-28; 1930-31
	Coeur d'Alene	1924; 1928-31
	Kaniksu	1922-24
	Nezperce	1924-33
	St. Joe	1927-28
	Selway (now Clearwater)	1924-34
	Selway (now Nezperce)	1926-34
Montana	Absaroka (now Gallatin)	1925-26
	Beaverhead	1925
	Bitterroot	1927
	Gallatin	1925-34
	Helena	1925-34
	Madison (now Beaverhead)	1925-29
Wyoming	Yellowstone National Park	1922-25
	INTERMOUNTAIN REGION	
Idaho	Boise	1922-24; 1927; 1929-31
	Lemhi (now Challis)	1923-24
	Sawtooth	1924; 1927; 1930
	Targhee	1927
	Weiser (now Payette)	1922-24; 1927; 1929-31
Wyoming	Bridger	1926
	Teton	1923-24
Utah	Cache	1927
	Uinta	1924
	Wasatch	1924
Nevada	Humboldt	1931

[1]See tables 4, 5, and 6 for documentation of specific outbreaks.

Table 2.--*Infestations by the western spruce budworm reported annually from National Forest Ranger Districts in the Northern Region, USDA Forest Service, 1922 through 1953*[1]

National Forest	Ranger district	1922-1930	1931-1940	1941-1950	1951-1953
		IDAHO			
Bitterroot	Magruder	----XXX-X	X--XX-----	----------	---
Clearwater	Bungalow	---------	-XX-------	----------	---
	Canyon	-------X-	----------	----------	---
	Lochsa	----XXXXX	XXXX------	----------	---
	Pierce	------XXX	X---------	----------	---
	Powell	--XXXXX--	---------	-----XXXXX	XXX
Coeur d'Alene	Kingston	--X---XXX	XXX-------	----------	---
	Magee	-------X-	----------	----------	---
	Wallace	---------	----------	X---------	---
Kaniksu	Priest Lake	XXX------	----------	----------	---
	Trout Creek	---------	----------	X---------	---
Nezperce	Clearwater	---XXXXXX	XXXX---XXX	XXXX------	---
	Elk City	----XXXX-	----------	----------	---
	Moose Creek	----XXXXX	XXXX------	----------	---
	Red River	--XXXXXXX	----------	----------	---
	Salmon River	----X----	----------	----XXXXXX	XXX
	Selway	----XXXXX	XXXXXXX---	----------	---
	Slate Creek	----XXX--	----------	----------	---
St. Joe	Avery	-----XX--	----------	----------	---
	Palouse	------X--	----------	----------	---
		WYOMING-MONTANA			
Yellowstone Natl. Park	North	XXXX-----	----------	----------	XXX
		MONTANA			
Beaverhead	Lima	---------	----------	--------X-	---
	Madison	-----XXX-	----------	X---------	--X
	Sheridan	---XX----	X---------	----------	---
	Wisdom	---X-----	----------	----------	X--
Bitterroot	Stevensville	-----X---	-------X--	----------	---
	Sula	---------	----------	----------	XXX
	West Fork	---------	-------X--	----------	XXX
Custer	Beartooth	---------	----XXXXXX	----------	---
Deerlodge	Boulder	---------	----------	----XXXXXX	XXX
	Deerlodge	---------	----------	----------	XXX
	Philipsburg	---------	----------	----------	XXX
	Whitehall	---------	----------	----XXXXXX	XXX

(con. next page; for footnotes see end of table)

Table 2. (con.)

National Forest	Ranger district	1922-1930	1931-1940	1941-1950	1951-1953
		MONTANA (con.)			
Flathead	Big Prairie	---------	----------	--XXXXXXXX	XX-
	Condon	---------	----------	------XXXX	XXX
	Coram	---------	--X-------	-----X----	---
	Spotted Bear	---------	----------	-XXXXXXXXX	XX-
	Swan Lake	---------	----------	-----X-XXX	XXX
Gallatin	Big Timber	---XX----	----------	----------	---
	Bozeman	-----XX--	-XXXX-XX--	XXXXXXXXXX	XXX
	Gardiner	---X-----	----------	----------	XXX
	Hebgen Lake	---------	----------	-X--------	---
	Livingston	---X-XXXX	XXXXX-XX--	--------XX	XXX
Helena	Canyon Ferry	--------X	XX--------	----XXXXXX	XXX
	Helena	---------	----------	----XXXXX-	---
	Lincoln	---------	----------	----------	XXX
	Townsend	---XXXXXX	XXXXXXXXXX	XXXXXXXXXX	XXX
Kootenai	Fortine	---------	--------X-	----------	---
Lewis & Clark	Belt Creek	---------	----------	------X---	---
	Judith	---------	----------	------X---	---
	Musselshell	---------	-XXXX-XX--	-----X-X-X	XXX
	Sun River	---------	----------	---------X	---
	Teton	---------	-------X--	---------X	---
	White Sulphur Springs	---------	----------	---XX-X-XX	XXX
Lolo	Bonita	---------	----------	-------XXX	XXX
	Seeley Lake	---------	-------XXX	X----XXXXX	XXX
	Superior	--------X	----------	----------	---
Glacier Natl. Park	Hudson Bay	---------	----------	-----XX---	---
	West Lakes	---------	----------	-----XXX-X	XX-

[1] X, budworm infestation within the District. Districts from which no infestations were reported during the 32-year period are not listed.

Table 3.--*Number of years outbreaks of the western spruce budworm were reported from administrative units*[1] *within the Northern and Intermountain Regions, 1948 through 1971*

State	Administrative unit	No. years outbreaks reported
	NORTHERN REGION (21 years: 1948-56; 1960-71)[2]	
Washington	Colville	1
	Kaniksu	2
Idaho	Bitterroot	9
	Clearwater	13
	Coeur d'Alene	0
	Kaniksu	1
	Nezperce	17
	St. Joe	3
	Craig Mountain (private)	12
Montana	Beaverhead	16
	Bitterroot	17
	Custer	6
	Deerlodge	19
	Flathead	11
	Gallatin	18
	Helena	21
	Kootenai	0
	Lewis & Clark	16
	Lolo	18
	Garnet Range, BLM	12
	Judith Mts., BLM	6
	Centennial Valley, BLM	1
	Sweetwater Hills, BLM	1
	Glacier Natl. Park	3
Wyoming	Yellowstone Natl. Park	17
	INTERMOUNTAIN REGION (22 years; 1950-71)	
Idaho	Boise	20
	Caribou	5
	Challis	14
	Payette	19
	Salmon	16
	Sawtooth	17
	Targhee	16
Utah	Ashley	3
	Cache	0
	Dixie	0
	Fishlake	3
	Manti-LaSal	0
	Uinta	0
	Wasatch	0
Wyoming	Bridger	7
	Teton	5
Nevada	Humboldt	0
	Toiyabe	0

[1]All units are National Forests unless designated BLM (Bureau of Land Management) or named as National Parks.

[2]Not reported by individual National Forests, 1957-59.

Table 4.--*Infestations by the western spruce budworm reported by District Rangers in National Forests of the Northern Region from 1922 through 1953*

National forest[1]	Year	Ranger district[2]	Infested acreage[3]	Host tree species[4]	Pertinent infestation conditions, reporter, and references[5]
					WASHINGTON
Colville					No infestations reported
					IDAHO
Bitterroot (Nezperce)	1926	Magruder (Paradise)	NR	ES,DF	White Cap Cr., Canyon Cr., Selway R.; an estimated 300 trees are killed in these areas. (H. REGNES, D.R., 11/13/26) (*U271*)
		(Salmon Mt.)	65	DF	XIII Mt., Thompson Ridge, and the confluence of Stripe and Swet Crs. (R.C. FITZGERALD, D.R., 11/15/26) (*U271*)
	1927	(Paradise)	23,000	GF,ES,DF	In White Cap Cr. and Canyon Cr. drainages, 5% of all GF trees are killed in host stands comprising 70% GF, 15% ES, and 15% DF. An estimated 80% of 1927 growth tips of GF trees are infested compared to 10% on ES trees, and almost none on DF trees. (H. REGNES, D.R., 10/20/27) (*U271*)
	1928	(Paradise)	750	DF	An estimated 70% of all DF trees are infested in 1927 in infested areas in the Little Clearwater R. drainage. (H. REGNES, D.R., 11/13/28) (*U271*)
	1930	(Paradise)	5	ES	In Sec. 19, T.28N., R.14E. (C.K. SPAULDING, D.R., 10/23/30) (*U271*)
	1931	(Paradise)			"*...grosbeaks, flycatchers, and other small birds... increased very materially and seemed to have been instrumental in checking the spruce budworm (in recent years).*" (R. A. PHILLIPS, For. Supv., 11/25/31) (*U271*)
	1934	(Salmon Mt.)	200	DF	In Secs. 26-34, T.28N.,R.14E. "...noticed this condition (defoliation) on trees all over the District, but not in force except as noted." (R.C. FITZGERALD, D.R., 10/31/34) (*U257*)
	1935	(Salmon Mt.)	200	DF	Infestation terminated. (R.C. FITZGERALD, D.R., 12/6/35) (*U257*)
Clearwater (Selway)	1924	Powell (Powell)	32,000	ES,SF	Serious in 1924. (E. MACKAY, D.R., 11/7/25) (*U253,U297*)
	1925	(Powell)	32,000	ES,SF	No spread in 1925. (E. MACKAY, D.R., 11/7/25) (*U253*)
	1926	Lochsa (Lochsa, N3/4)	1,500	ES	Trees of all age classes are attacked throughout the ES type. (R.L. HAND, D.R., 10/21/26) (*U253*)
		(Middle Fk., N1/2)	NR	ES	An estimated 75% of trees of all age classes are attacked throughout the ES type; no tree mortality. (R. FERGUSON, D.R., 11/10/26) (*U253*)
	1927	(Middle Fk., N1/2)	NR	ES,DF,GF	An estimated 75% of the ES trees, 20% of the DF trees, and occasional GF trees above 4,000 feet elevation are attacked throughout the District. (R. FERGUSON, D.R., 11/8/27)(*U253*)
		Pierce (Musselshell)	7,000	DF,ES,GF	New; 3% of host species are attacked. (P.H. GERRARD, Asst. For. Supv., 11/26/27) (*U259*)
(Lolo)	1927	Powell (Elk Summit)	15,000	ES,DF,GF	Scattered throughout Moose Cr. area, increasing. (W.J. BELL, D.R., 11/9/27) (*U270*)
		(Powell)	75,000	SF,ES	Scattered from Papoose Cr. east to Montana border; increasing. (E. MACKAY, D.R., 11/7/27) (*U271*)
(Selway)	1928	Lochsa (Lochsa, N3/4)	11,200*	ES,SF,DF,GF, LPP	Few dead trees were noted. (R.L. HAND, D.R., 10/23/28) (*U253*)

(con. next page; for footnotes see end of table)

Table 4. (con.)

National Forest	Year	Ranger district	Infested acreage	Host tree species	Pertinent infestation conditions, reporter, and references
Clearwater (Selway)	1928	Lochsa (Middle Fk.,N1/2)	40,000*	DF,GF,ES,SF	General throughout the District above 2,500 feet elevation; heaviest in DF and GF stands above 4,000 feet. About 35% of all SF trees and 25% of all ES trees are infested. Some overmature GF stands contain topkilled trees, presumably from prior infestations. (R. FERGUSON, D.R., 11/9/28)(*U253*)
(Selway)	1928	Pierce (Mussel-shell)	6,600	GF	Forks of Lolo Cr. and on French Mt.; sawlog size trees. (J.E. KAUFFMAN, D.R., 10/30/28) (*U259*)
(Lolo)	1928	Powell (Elk Summit)	15,000	ES,GF,DF	In the Moose Cr. drainage. (L.D. ROBINSON, D.R., 11/21/28) (*U270*)
		(Powell)	30,000	SF,ES	Static in the Squaw Cr. and Papoose Cr. areas. (E. MACKAY, D.R., 11/12/28) (*U270*)
Clearwater	1929	Canyon	80	DF,GF	Active in the Beaver Cr. drainage during the past years. (O.A. KNAPP, D.R., 11/20/29) (J.E. KAUFMANN, D.R., Chamberlain R.D., 10/28/30) (*U259*)
Clearwater (Selway)	1929	Lochsa (Lochsa, N3/4)	9,400*	ES,SF,DF,GF, LPP	No change over 1928; *infested acreage was reduced from forest fires this year.* (R.L. HAND, D.R., 11/7/29) (*U253*)
		(Middle Fk.,N1/2)	39,000*	GF,DF,ES	No change over 1928. (R. FERGUSON, D.R., 11/11/29) (*U253*)
(Lolo)	1929	Powell (Elk Summit)	15,000	GF,DF,ES	In the Moose Cr. area; decreasing. (F. OTTER, D.R., 11/11/29) (*U270*)
		(Powell)	17,000	ES,GF	In the Squaw Cr. and Papoose Cr. areas; very light. (E. MACKAY, D.R., 11/12/29) (*U270*)
Clearwater (Selway)	1930	Lochsa (Lochsa, N3/4)	22,500*	ES,GF	All trees are infested in the ES and GF types from 4,000 to 6,000 feet elevation. (F. W. SHANER, D.R., 9/25/30) (*U253*)
		(Middle Fk.,N1/2)	39,000*	GF,DF,ES	Generally lighter; *defoliation may be masked by damage from numerous hailstorms.* More dead trees appearing. (R. FERGUSON, D.R., 11/8/30) (*U253*)
Clearwater	1930	Pierce (Mussel-shell)	NR	GF,DF,ES	Decreasing. (R. JOHANSON, D.R., Musselshell, R.D., 11/3/30) (*U259*)
Clearwater (Selway)	1931	Lochsa (Middle Fk., N1/2)	20,000*	DF,GF,ES,SF	Decreased throughout. (R. FERGUSON, D.R., 11/2/31) (*U253*)
Clearwater	1932	Bungalow	1,500	DF,GF	In the Elk Mt. area; trees 50 to 60 years old are infested. (W.L. CLOVER, D.R., Oxford R.D., 9/5/32) (*U259*)
Clearwater (Selway)	1932	Lochsa (Middle Fk., N1/2)	10,000*	DF,GF	Decreased, attacks lighter; dead limbs beginning to appear from defoliation in the previous years. (R. FERGUSON, D.R., 11/10/32) (*U253*)
		(Selway, N1/4)	15,000*	ES,GF	Light in host stands between 4,000 and 6,000 feet elevation. (F.W. SHANER, D.R., 11/4/32) (*U253*)
Clearwater	1933	Bungalow	1,500	DF,GF	Elk Mt. area; all-aged host trees infested. (F. MENEALY, D.R., Oxford R.D., 8/28/33) (*U259*)
Clearwater (Selway)	1933	Lochsa (Middle Fk.,N1/2)	32,000*	GF,DF	Very light. (R. FERGUSON, D.R., 11/15/33) (*U253*)
		(Selway, N1/4)	NR	ES,GF	NR in 1933; referred to in 1934 report. (F.W. SHANER, D.R., 11/21/34) (*U253*)

(con. next page; for footnotes see end of table)

Table 4. (con.)

National Forest	Year	Ranger district	Infested acreage	Host tree species	Pertinent infestation conditions, reporter, and references
Clearwater (Selway)	1934	Lochsa (Selway, N1/4)	3,500	ES,GF	Increased over that in 1933; *considerable infested forest was burned this year.* (F.W. SHANER, D.R., 11/21/34) (*U253*)
(Lolo)	1946	Powell (Powell)	100,000	ES,GF	Very heavy in the Papoose Cr. drainage. (H.J. VICHE, D.R., 11/20/46) (*U270*)
	1947	(Powell)	100,000	ES,GF,SF	Decreased in the Lochsa R. drainage. (H.A. STREED, D.R., 12/3/47) (*U270*)
	1948	(Powell)	100,000	SF,ES,DF,GF	Scarcely evident in the Lochsa R. drainage. (W.R. MOORE, D.R., 11/5/48) (*U270*)
(Lolo)	1949	Powell (Powell)	25,000*	DF,ES,SF,GF	New but declining in the Beaver Cr., Storm Cr., and White Sand Cr. drainages and on Dan and Savage Ridges. (W.R. MOORE, D.R., 10/24/49) (*U270*)
	1950	(Powell)	NR	DF,ES,SF,GF	Declined. Defoliation was heavy from budworm feeding in 1949 in the White Sand Cr. and Storm Cr. areas. (W.R. MOORE, D.R., 11/13/50) (*U270*)
	1950	(Powell)	10,600	DF,GF,SF	(R.E. DENTON, Entomol., Bur. Entomol. and Plant Quar., Coeur d'Alene, Idaho, Feb. 1952 and 7/29/50) (*U41*)
	1951	(Powell)	NR	DF,ES,SF,GF	Mostly declined throughout the District; some new infestations in the Storm Cr. and Haskell Cr. drainages. (W.R. MOORE, D.R., 10/3/51) (*U271*)
			23,700	DF,GF,SF	Defoliation was heavy on 5,000 acres of new infestation south of Lolo Divide. No tree mortality has been observed to date in any infested area, but some topkilling of trees is evident. (R.E. DENTON, Entomol., Bur. Entomol. and Plant Quar., Coeur d'Alene, Idaho, Feb. 1952) (*U44*)
Clearwater (Lolo)	1952	(Powell)	80,400	SF,DF,ES	Heavy defoliation was seen only on 5,400 acres in the Cabin Cr. and Haskell Cr. areas. *Defoliation throughout infested areas is heaviest in SF trees, least in ES trees.* (R.E. DENTON, Entomol., Bur. Entomol. and Plant Quar., Coeur d' Alene, Idaho, 11/6/52) (*U45*)
	1953	(Powell)	NR	SF	Extensive feeding noted, mostly on SF understory trees in the Storm Cr., Brushy Cr., and Haskell Cr. areas. Aerial spraying is planned for these areas in 1954. (W.R. MOORE, D.R., 9/23/53) (*U270*)
Coeur d'Alene	1924	Kingston	NR	DF,GF	Covered a considerable area in the Steamboat Cr. and Cougar Cr. areas; in "minor (host) species." Apparently continuing from preceding years. A smaller area in the N.Fk. Coeur d'Alene R. drainage, of more recent origin. (W.W. WHITE, Forester, For. Serv., North. Reg., Missoula, Mont., 1/9/25) (*U297*)
	1928	Kingston (Lower N. Fk.)	16,800	GF	In the Steamboat, Cougar, and Grizzly Cr. drainages. (C.B. HAND, D.R., 11/3/28) (*U260*)
	1929	Kingston-Fernan (Little River)	30,000	GF,DF,ES,WWP	Attacks were severe in the Laverne Cr. and Lieberg Cr. areas. (G.S. HAYNES, D.R., 11/13/30) (*U260*)
		Magee	NR	GF,DF,WH,ES	Tepee Summit, NW 1/4, Sec. 23, T.51N., R.1E.; heaviest in the GF type. (J.C. EVENDEN, Entomol., Bur. Entomol., Coeur d'Alene, Idaho, 10/1/29) (Unpubl. field notes filed at For. Sci. Lab., For. Serv., Moscow, Idaho)
	1930	Kingston-Fernan (Little River)	30,000	GF,DF,ES	Decreased in the Laverne Cr. and Lieberg Cr. areas. (G.S. HAYNES, D.R., 11/13/30) (*U260*)

(con. next page; for footnotes see end of table)

Table 4. (con.)

National Forest	Year	Ranger district	Infested acreage	Host tree species	Pertinent infestation conditions, reporter, and references
Coeur d'Alene	1931	Kingston (Little River)	30,000	GF,DF,ES	Heavy in the Cougar Cr. drainage. (G.S. HAYNES, D.R., 11/23/32) *(U260)*
	1932	(Little River)	30,000	GF,DF,ES	Static. (G.S. HAYNES, D.R., 11/23/32) *(U260)*
	1933	Kingston-Fernan (Little River)	20,000	GF,DF,ES,WWP	In the Laverne Cr. and Lieberg Cr. areas. (G.S. HAYNES, D.R., 11/15/33) *(U260)*
	1941	Wallace	NR	SF	In the head of Cottonwood Cr., T.50N.,R.5E. (C.H. SCRIBNER D.R., Trout Cr. R.D., Cabinet N.F., Idaho, 11/21/41) *(U258)*
Kaniksu	1922	Priest Lake (Bismark)	NR	WH	A report was made of WH trees killed by undetermined insects at Priest Lake, Idaho. (J. A. FITZWATER, For. Supv., Newport, Wash., Jan. 1922) *(35,36,37,U60)*
	1922	Priest Lake (Bismark)	NR*	WH,WWP,GF,WL, ES,WR	Feeding larvae were collected from named hosts from parts of Secs. 1-2, T.60N., R.5W.; Sec. 6, T.60N.,R.4W.; Secs. 23-26, 35-36, T.61N.,R.5W.; and Secs. 19,30-31, T.61N., R.4W. between Kalispell Cr. and Reeder Cr. (H.J. RUST, Entomol., Ranger, Bur. Entomol., Coeur d'Alene, Idaho Original field notes and map, 6/27/22). *Subsequent determination of reared adults as* Harmologa fumiferana *(Clemens) by C. HEINRICH, Insect Taxonomist, Washington, D.C., makes this the first spruce budworm infestation of record in the Western United States.* *(35,36,37,U60)*
	1923	Priest Lake (Bismark)	NR	WH,WWP,GF	In the Kalispell Cr. area, mostly noted in WH reproduction, saplings, and poles in cutover areas. Some WWP and GF reproduction was infested. Defoliation was less than in 1922. (H.J. RUST, Entomol. Ranger, Bur. Entomol., Coeur d'Alene, Idaho. Original field notes, 7/16/23)
	1924	Priest Lake (Bismark)	NR	WH,WWP,ES,GF	Continued in the Kalispell Cr. timber sale area; younger trees are the most defoliated. Proposed control of budworm in connection with eradication of WH on sale area is questioned. (W.W. WHITE, Forester, For. Serv., Northern Reg., Missoula, Mont., 1/9/25) *(U297)*
Kaniksu (Cabinet)	1941	Trout Creek (Trout Creek)	300	SF	In the head of the E.Fk. Trout Cr. drainage. The insect responsible was not identified, inasmuch as collected specimens were lost, but from the District Ranger's description of the larvae, moths, and host tree damage, the budworm was suspect. (C.H. SCRIBNER, D.R., 11/21/41) *(U258)*
Nezperce	1924		NR	NR	"The spruce budworm is found in large numbers all over the Forest. Just how serious the loss from the epidemic is cannot yet be predicted." (W.W. WHITE, Forester, For. Serv., Northern Reg., Missoula, Mont., 1/9/25) *(U297)*
		Red River	55,700	DF	In the Bargamin, Otterson, Lower Big Mallard Crs. drainages. From 10% to 20% of the host stands are infested in these drainages. (E. McCONNELL, D.R., 11/2/25) *(U271)*
	1925	Clearwater	600	GF,DF,ES	Declined on Grouse Cr. Ridge; light attacks noted elsewhere in the District. (V. L. COLLINS, D.R., 11/14/25) *(U271)*
		Red River	55,700	DF	No change in the infestation over that in 1924. (E. McCONNELL, D.R., 11/2/25) *(U271)*

(con. next page; for footnotes see end of table)

Table 4. (con.)

National Forest	Year	Ranger district	Infested acreage	Host tree species	Pertinent infestation conditions, reporter, and references
Nezperce	1926	Clearwater	NR	GF,DF,ES LPP,WL	Occasional trees were defoliated throughout District (V.L. COLLINS, D.R., 11/16/26) (*U271*). Attacks were heaviest on GF trees, thence on DF trees, and least on trees of other hosts. (L.C. HURTT, For. Supv., 11/16/26) (*U271*)
		Elk City	1,000	GF,DF	In the vicinity of Orogrande. (D.R., unidentified, 11/2/26) (*U271*)
			7,000	GF,DF	East Newsome Cr. basin; new infestation. (C.D. BLAKE, Asst. For. Supv., 11/22/26) (*U271*)
Nezperce (Selway)	1926	Moose Creek (Moose Cr., all)	3,000	GF,ES,DF,PP	First year; throughout the eastern part of the District. (F.W. SHANER, D.R., 11/1/26) (*U253*)
		(Bear Cr., N1/2)	NR	ES,SF	General throughout the ES-SF type. (J.A. PARSELL, D.R., 11/29/26) (*U253*)
		(Lochsa, S1/4)	500	ES	Increased in high-elevation ES stands. (R.L. HAND, D.R., 10/21/26) (*U253*)
	1926	Red River	55,700	DF,GF	Same as in 1925. E. McCONNELL, D.R., 11/11/26) (*U271*)
		Selway (Selway, all)	120	ES	On Iron Mt.; increased rapidly. (C.S. CROCKER, D.R., 11/7/26) (*U253*)
		(Middle Fk., S1/2)	NR	ES	Most all ES stands on the District are infested. Increased. No tree mortality was noted. (R. FERGUSON, D.R., 11/10/26) (*U253*)
Nezperce	1926	Slate Creek	NR	GF,DF,WL	Increased. (Reported tree mortality was later disputed by the Forest Supervisor.--Authors.) (H.W. HIGGINS, D.R., 11/5/26) (*U271*)
	1927	Clearwater	NR*	GF,DF,ES,SF, LPP, WL	Most host stands were infested throughout District; heaviest in the DF-GF type, least in the DF-PP type. (V.L. COLLINS, D.R., 11/15/27) (*U271*)
	1927	Elk City	NR*	ES,GF,DF,SF	All firs were infested throughout District. (D.R., unidentified, 11/2/27) (*U271*)
Nezperce (Selway)	1927	Moose Creek (Bear Cr., N1/2)	250*	DF,GF,ES	Increased in the Crow Cr., Cub Cr., and Brush Fork Cr. areas. (L.W. LEWIS, D.R., 11/19/27) (*U253*)
		(Lochsa, S1/4)	2,000*	ES,SF,LPP	Increased in the ES type throughout the District; no tree mortality seen. (R.L. HAND, D.R., 10/17/27) (*U253*)
		(Moose Cr., all)	NR*	GF,ES,DF	Most host stands were infested throughout District; increased in severity. Dead GF trees were observed in the Indian (Pettibone) Cr. area. (F.W. SHANER, D.R.,10/18/27) (*U253*)
Nezperce	1927	Red River	53,800*	DF,GF	In the Bargamin Cr., Moose Cr., Otterson Cr., and lower Big Mallard Cr. drainages. (EARL McCONNELL, D.R., 11/3/27). Attacks in Bargamin Cr. appeared greater than indicated. (C.D. BLAKE, Acting For. Supv.) (*U271*)
Nezperce (Selway)	1927	Selway (Meadow Cr., all)	NR	GF	Increased in GF stands throughout the District; defoliation was not severe. (A.C. CAMPBELL, D.R., 11/21/27) (*U253*)
		(Middle Fk., S1/2)	NR	ES,DF,GF	Host stands above 4,000 feet elevation were infested throughout the District; about 75% of the ES trees, 20% of the DF trees, and an occasional GF tree were infested. (R. FERGUSON, D.R., 11/8/27) (*U253*)
		(Selway, all)	50,000	ES	All ES stands were infested in the Iron Mt.-Beargrass Pt. area; increased. (C.S. CROCKER, D.R., 10/24/27) (*U253*)
Nezperce	1927	Slate Creek	96,000*	GF,DF,ES,WL, LPP	New this year; increased in all host types between 2,000 and 6,500 feet elevation. Defoliation was heaviest on DF, GF, and ES trees, sparse and only occasional on WL and LPP trees. (O.V. CLOVER, D.R., 12/8/27) (*U271*)

(con. next page; for footnotes see end of table)

Table 4. (con.)

National Forest	Year	Ranger district	Infested acreage	Host tree species	Pertinent infestation conditions, reporter, and references
Nezperce	1928	Clearwater	NR	GF,SF,DF,ES, LPP, WL	Same areas were infested as in 1927; defoliation was less than in 1926 or 1927. (V.L. COLLINS, D.R.,11/16/28) (*U271*)
		Elk City	NR	DF,GF,ES	Same areas were infested as in 1927, but there was about 50% less defoliation. (G.C. SPACE, D.R.,11/15/28)(*U271*)
Nezperce (Selway)	1928	Moose Cr. (Bear Cr., N1/2)	600*	GF,DF	Increased in the Crow Cr. and S.Fk. Running Cr. drainages. (L.W. LEWIS, D.R., 11/1/28) (*U253*)
		(Lochsa, S1/4)	2,800	ES,SF,GF,DF, LPP	Static in the Lake Cr., Lost Cr., and Indian Grave Cr. drainages. (R.L. HAND, D.R., 10/23/28) (*U253*)
		(Moose Cr., all)	40,000*	ES,GF	Increased in severity throughout the District; trees were beginning to die in older infested areas. (F.W. SHANER, D.R., 10/26/28) (*U253*)
Nezperce	1928	Red River	53,800	DF,GF	Same areas were infested as in 1927; defoliation was less severe. (E. McCONNELL, D.R., 11/13/28) (*U271*)
Nezperce (Selway)	1928	Selway (Meadow Cr., all)	90,000*	GF,DF,ES,LPP	Increased in severity throughout the District, particularly in GF stands. (A.C. CAMPBELL, D.R., 11/8/28) (*U253*)
		(Middle Fk.,S1/2)	40,000*	DF,GF,ES,SF	Most host stands were infested throughout the District; infestation increased in severity, particularly in mature stands. (R. FERGUSON, D.R., 11/9/28) (*U253*)
		(Selway, all)	50,000*	ES,GF	Heavy defoliation, becoming greater, was evident in all ES-GF stands above 5,000 feet elevation in the Iron Mt.-Beargrass Pt. area. No tree mortality was seen. (C.S. CROCKER, D.R., 10/29/28) (*U253*)
Nezperce	1928	Slate Creek	164,000	GF,DF	Decreased defoliation, scarcely detectable. (O.V. CLOVER, D.R., 11/22/28) (*U271*)
	1929	Clearwater	NR	GF,SF,DF,ES, LPP, WL	Same areas were infested as in 1927 and 1928. New foliage growth was almost completed before defoliation from larval feeding was detectable. (V.L. COLLINS, D.R., 11/15/29)(*U271*)
		Elk City	NR	DF,GF,ES	Decreased in severity throughout District. (GEORGE R. SPACE, D.R., 11/6/29) (*U271*)
Nezperce (Selway)	1929	Moose Cr. (Bear Cr., N1/2)	5,000	GF,DF	Same as in 1928; increased. (L.W. LEWIS, D.R., 10/14/29) (*U253*)
		(Lochsa, S1/4)	2,100	ES,SF,GF,DF	Static. (R.L. HAND, D.R., 11/7/29) (*U253*)
		(Moose Cr., all)	40,000	ES,GF	Same areas were infested as in 1928; increased in severity. (F.W. SHANER, D.R., 10/26/29) (*U253*)
Nezperce	1929	Red River	53,800	DF,GF	Declined in severity in 1928-infested areas. (E. McCONNELL, D.R., 11/1/29) (*U271*)
Nezperce (Selway)	1929	Selway (Meadow Cr., all)	26,600*	GF,DF,ES	Declined in severity in 1928-infested areas; GF trees were the most severely defoliated of the principal host trees. (A. C. CAMPBELL, D.R., 11/8/29) (*U253*)
		(Middle Fk.,S1/2)	39,000*	GF,DF,ES	Static; some patches of host reproduction were killed. (R. FERGUSON, D.R., 11/11/29) (*U253*)
		(Selway, all)	31,000*	GF,ES	Observed throughout the southern part of the District; infested areas diminished, *but defoliation of GF trees was greater than in 1928. Top-killing of trees common in ES and GF stands,* but no tree mortality evident. *Seed crops have been very light in stands infested during past 3 years; the District Ranger questioned whether budworm was responsible.* (C. S. Crocker, D. R., 10/24/29) (*U253*)

(con. next page; for footnotes see end of table)

Table 4. (con.)

National Forest	Year	Ranger district	Infested acreage	Host tree species	Pertinent infestation conditions, reporter, and references
Nezperce	1930	Clearwater	NR	GF	Increased to previous levels of severe defoliation in all GF stands throughout the entire District between 4,000 and 6,000 feet elevation. (V.L. COLLINS, D.R., 11/19/30)(*U271*)
Nezperce (Selway)	1930	Moose Creek (Bear Cr., N1/2)	NR*	ES,GF,DF	(L.W. LEWIS, D.R., 10/18/30) (*U253*)
		(Lochsa, S1/4)	1,000*	ES,GF	In the Lochsa R. drainage; static. (F.W. SHANER, D.R., 9/25/30) (*U253*)
		(Moose Cr., all)	41,200*	SF,ES	In the Three Link Cr., Martin Cr., Big Cr., and Indian Cr. drainages; static. (G.W. CASE, D.R., 11/3/30) (*U253*)
Nezperce	1930	Red River	63,000*	DF,GF	Severity of infestation diminished to pre-1927 level; 20% of the host timber in Bargamin Cr. and Otterson Cr., 10% in Big Mallard Cr. and Moose Cr., and 2% in the Meadow Cr. drainage was infested. (E.McCONNELL, D.R., 11/10/30)(*U271*)
Nezperce (Selway)	1930	Selway (Meadow Cr., all)	600*	GF,DF	On Green Ridge, Indian Hill Ridge, and on the north slopes of the Selway R. drainage; decreased (apparently new or previously unreported infestations.--Authors.) (A.C. CAMPBELL, D.R., 10/19/30) (*U253*)
		(Middle Fk., S1/2)	39,000*	GF,DF,ES	No spread; decreased defoliation. Tree mortality began to appear in second-growth host stands continuously infested during the past 3 years. (R. FERGUSON, D.R, 11/9/30) (*U253*)
		(Selway, all)	50,000*	GF,ES	Same as in 1929, did not spread. Defoliation was heavy on 20,000 acres, lighter on 30,000 acres. No tree mortality seen. *Very poor seed crops were evident in infested stands.* (C.S. CROCKER, D.R., undated) (*U253*)
Nezperce	1931	Clearwater	NR	GF,DF,ES,SF, LPP, WL	Most of the fir types on the District were infested, but 1931 foliage was only partially destroyed. Top-killing of host trees was very prevalent from the cumulative defoliation of past few years. (V.L. COLLINS, D.R., 11/18/31)(*U271*)
Nezperce (Selway)	1931	Moose Creek (Bear Cr., N1/2)	1,800*	GF,DF	In the Mink Cr., Martin Cr., and Brushy Fork Cr. drainages; decreased in severity. (L.W. LEWIS, D.R., 11/17/31) (*U253*)
		(Lochsa, S1/4)	NR*	NR	NR
		(Moose Cr., all)	NR*	NR	NR
		Selway (Meadow Cr., all)	500*	GF,DF	Groups of infested host trees were scattered on Green Ridge and along the north slopes of the Selway R. drainage; many trees have died from attacks in 1930. Decreased infestation. (A.C. CAMPBELL, D.R., 10/27/31) (*U253*)
		(Middle Fk., S1/2)	NR*	DF,GF,ES,SF	Infestations that increased from 1927 to 1929 decreased in 1930 and 1931. Defoliation was still heavy in 1931 in the vicinity of Corral Hill and Frenchman Butte. (R. FERGUSON, D.R., 11/2/31) (*U253*)
		Selway (Selway, all)	50,000*	GF,ES	Less severe than in 1928-1930. (C.S. CROCKER, D.R., 9/22/31) (*U253*)
Nezperce	1932	Clearwater	NR	GF,SF	Light in all fir types throughout the District; infestations have been continuous since 1923. (V.L. COLLINS, D.R., 11/2/32) (*U271*)
Nezperce (Selway)	1932	Moose Cr. (Moose Cr., all)	NR*	SF,ES	Very light in host types at higher elevations throughout the District; decreased. (G.W. CASE, D.R., 11/5/32)(*U253*)
		Selway (Meadow Cr., all)	500*	GF	Decreased. Abundant top killing and mortality of host trees resulted from the infestations of 1932 and previous years. (A.C. CAMPBELL, D.R., 9/28/32) (*U253*)

(con. next page; for footnotes see end of table)

Table 4. (con.)

National Forest	Year	Ranger district	Infested acreage	Host tree species	Pertinent infestation conditions, reporter, and references
Nezperce (Selway)	1932	(Middle Fk., S1/2)	160,000*	DF,GF	Declining. (R. FERGUSON, D.R., 11/10/32) (*U253*)
		(Selway, all)	60,000*	ES,GF	Decreased. (Acreage of mapped infestations appears smaller than reported.--Authors). (F.W. SHANER, D.R., 11/4/32)(*U253*)
Nezperce	1933	Clearwater	NR	GF,SF	Extent was the same as that in 1932, but with decreased host damage. (V.L. COLLINS, D.R., 11/16/33) (*U271*)
Nezperce (Selway)	1933	Moose Cr. (Moose Cr., all)	40,000*	ES,SF,GF	Increased in the Indian Cr., Battle Cr., Moose Cr., Squaw Cr., Bear Cr., and Martin Cr. drainages; occasional pole-size host trees were killed. (G.W. CASE, D.R., 11/28/33) (*U253*)
		Selway (Middle Fk., S1/2)	NR*	GF,DF	General throughout the District since 1927, heaviest at first in host stands from 5,000 to 6,000 feet in elevation. Infestations were most active during 1928 and 1929 when very heavy host tree damage was noted. Generally declining infestations during 1930 and 1931 but with scattered pockets of heavy host tree damage. Further declining infestations in 1932 and 1933 centered in overmature GF stands in the Clear Cr., Goddard Cr., and Hamby Cr. drainages. The accompanying map identifies one area very heavily infested from 1928 to 1932 in which about 75% of the host trees were dead; other areas shown to be still heavily infested contained stands in which about 10% of the host trees were dead and about 15% of the remainder were topkilled. Nearly all the latter stands comprised overmature, long-decadent GF trees. (R. FERGUSON, D.R., 11/15/33) (*U253*)
		(Selway, all)	NR*	ES,GF	Many host stands in the western part of the District showed an increasing incidence of attacks and of tree mortality. (F.W. SHANER, D.R., 10/29/33) (*U253*)
	1934	Moose Cr. (Moose Cr., all)	20	ES,SF	Drastically decreased. Infested host trees average 18 inches d.b.h. (G.W. CASE, 10/24/34) (*U253*)
		Selway (Middle Fk., S1/2)	NR	GF,DF	Apparently terminated. In some areas infested since 1927, 70% of the trees were dead in patches of host type covering up to 20 or 30 acres, although the overall cumulative tree mortality Districtwide was only about 2%. Many host trees adjudged to be dead or dying in previous years are apparently surviving. (C.A. MacGREGOR, D.R., 11/27/34) (*U253*)
		(Selway, all)	14,000	ES,GF	Slight increase. About two of every three trees in the host types were infested. *Much budworm-infested timber was burned this year*. (F.W. SHANER, D.R., 11/21/34) (*U253*)
Nezperce	1935	Clearwater	NR	GF,SF	Diminished. Although most of the GF foliage throughout the District has been fed upon heavily since 1924, almost none was eaten in 1935. (V.L. COLLINS, D.R.,11/15/35) (*U271*)
		Selway (Middle Fk., S1/2)	150	DF	Dying out, but defoliation was noted this year in the S.Fk. Canyon Cr. area. It was estimated that budworm defoliation since 1928 had killed 10% of the GF and SF trees above 3,000 feet elevation, and that 50% of these tree species had been killed in the head of the Goddard Cr., Hamby Cr., and Clear Cr. drainages. (C.A. MacGREGOR, D.R., 11/15/35) (*U271*)
		Selway	60,000*	ES,GF	Static in the south side of the Selway R. from O'Hara to Meadow Crs., except for spot increases. Approximately 60% of the ES and GF types were infested; in these, about 20% of the trees appeared to have died from cumulative defoliations. (C.D. SOUSLEY, D.R., 11/7/35) (*U271*)
	1936	Selway	60,000	GF,ES	Spots of light infestation were detected throughout the District. (C.D. SOUSLEY, D.R., 11/11/36) (*U271*)

(con. next page; for footnotes see end of table)

Table 4. (con.)

National Forest	Year	Ranger district	Infested acre	Host tree species	Pertinent infestation conditions, reporter, and references
Nezperce	1937	Clearwater	NR	GF,SF	Less than 1% of the host trees in the District were infested. (B.A. GOODMAN, D.R., 11/24/37) (*U271*)
		Selway	60,000	GF,ES	Static; mostly restricted to GF stands. (C.D. SOUSLEY, D.R., 11/5/37) (*U271*)
	1938	Clearwater	NR	GF,SF	Static. (B.A. GOODMAN, D.R., 11/9/38) (*U271*)
	1939	Clearwater	NR	GF,SF	Static; same as in 1937 and 1938. (B.A. GOODMAN, D.R., 11/13/39) (*U271*)
	1940	Clearwater	NR	GF,SF	Declined in severity; larger host trees only were infested at higher elevations. (C.S. WALKER, D.R., 11/13/40) (*U271*)
	1941	Clearwater	NR	GF	Infested trees up to 12 inches d.b.h. occurred singly, no more than four or five per section throughout the District. (C. S. WALKER, D.R., 11/3/41) (*U271*)
	1942	Clearwater	NR	GF	Same as in 1941. (R. L. SPACE, D.R., 11/19/42) (*U271*)
	1943	Clearwater	NR	GF	Same as in 1941. (R. L. SPACE, D.R., 12/2/43) (*U271*)
	1945	Salmon R.	NR	DF	In the Kessler Cr. drainage. (R.B. JORGENSEN, D.R., 11/10/47) (*U271*)
	1946	Salmon R.	NR	DF	Same as in 1945. (R.B. JORGENSEN, D.R., 11/10/47)(*U271*)
	1947	Salmon R.	NR	DF	Increased at scattered locations throughout the District. Trees infested in Kessler Cr. in 1945 and 1946 were now dead. (R.B. JORGENSEN, D.R., 11/10/47) (*U271*)
	1948	Salmon R.	NR	DF (mostly), GF	1947-reported infestations increased in severity. (R.B. JORGENSEN, 11/12/48) (*U271*)
	1949	Salmon R.	NR	DF,GF	Increased. Light to heavy defoliation throughout the District, heaviest in the Sherwin Cr., Cow Cr., Bean Cr., W.Fk. Race Cr., and W.Fk. Rapid R. drainages. (R.B. JORGENSEN, D.R., 11/14/49) (*U271*)
	1950	Salmon R.	NR	DF,GF	Same as in 1949. Host tree mortality increased from cumulative defoliation of past several years. (R.B. JORGENSEN, D.R., 11/7/50) (*U271*)
	1951	Salmon R.	NR	DF,GF,ES	Increased throughout the District. Defoliation was heaviest in previously infested host stands in the Sherwin Cr., Cow Cr., Bean Cr., W.Fk. Race Cr., and W.Fk. Rapid R. drainages; also heavy in first-year infestations in the Oxbow Cr., Wygant Cr., Papoose Cr., and W.Fk. Rapid R. drainages and on Whitebird Ridge. (R.B. JORGENSEN, D.R., 10/8/51) (*U271*)
	1953	Salmon R.	NR	DF,GF,ES	Defoliation was general over the District. Approximately 16,070 acres of infested host type in the Papoose Cr. and Bean Cr. drainages were aerially sprayed in July with DDT. (J.R. ALLEY, D.R., 11/24/53) (*U271*)
St. Joe	1927	Avery (Roundtop)	160*	ES	In Sec. 12, T.43N.,R.5E., Twin Cr. Administrative Site (now Twin Cr. Campground). Increased in 0- to 80-year-old ES stands. (H.L. FLODBERG, D.R., 11/8/27) (*U272*)
	1928	Avery	NR	ES	Confined to scattered host trees. Not serious. (L.M. DUNN, D.R., 10/29/28) (*U272*)
	1928	Palouse	30*	WL	In Secs. 1-2, T.42N.,R.3E., on the ridge between Mannering and E.Fk. Meadow Crs. (near Giant White Pine Tree). Scattered patches of 1 to 3 acres of 30-year-old host trees (5 inches and smaller) were infested. First season attacks were observed. (W.H. DAUGS, D.R., 11/14/28) (*U272*)

(con. next page; for footnotes see end of table)

Table 4. (con.)

National Forest	Year	Ranger district	Infested acreage	Host tree species	Pertinent infestation conditions, reporter, and references
					MONTANA
Beaverhead (Madison)	1925	Sheridan (Ruby, all)	6*	DF	In S1/2 Sec. 4, T.9S.,R.3W. Static. (B.P. MARTIN, D.R., 11/14/25) (*U250*)
Beaverhead		Wisdom	0.5	ES	In T.1N. and T.1S.,R.17W., upper Johnson Cr. drainage. Slowly increased. (M.G. RAMSEY, D.R., 11/1/25) (*U256*)
Beaverhead (Madison)	1926	Sheridan (Ruby, all)	6	DF	Same area as in 1925, but with decreasing defoliation. (B.P. MARTIN, D.R., 11/14/26) (*U250*)
	1927	Madison (Lyon)	800	ES	In Secs. 10,11,14,15; T.12S.;R.2W.; Cascade Cr. drainage. Increased defoliation. (C.A. JOY, D.R., 11/9/27) (*U250*)
	1928	(Lyon)	800	ES	Same areas as in 1927; static. (C.A. JOY, D.R.,11/14/28) (*U250*)
	1929	(Lyon)	800	ES	Same areas as in 1928; static. (C.A. JOY, D.R., 11/15/29) (*U250*)
Beaverhead	1931	Sheridan	NR	ES,DF	Stonewall and other areas in the Tobacco Root Mts. and in the upper Ruby R. drainage. New. Young age classes of host trees were infested. (H.E. SCHWAN, D.R., 11/23/31) (*U256*)
	1941	Madison	NR	ES	Most all ES seedlings and saplings in the District were infested to some degree. Tree mortality was rare. (E.W. STEIN, D.R., 11/21/41) (*U256*)
	1949	Lima	NR	DF(?)	Scattered in open-type host stands throughout the District. (E.E. REDMAN, For. Supv., 11/29/49) (*U256*)
	1951	Wisdom	NR	ES,SF	Endemic throughout the District. (E.E. REDMAN, For. Supv., 10/12/51) (*U256*)
	1953	Madison (Ennis)	NR	DF	Moderate to severe defoliation was noted on 690 acres in the Meadow Cr. drainage; light defoliation was evident in all other DF stands throughout the District. Damage increased in the Tobacco Root Mts. (W.H. MacKENZIE, D.R., 10/13/53) (*U256*)
		Madison	20,000	DF	Defoliation increased generally, but decreased in severity from north to south in an area comprising the Wigwam Cr., Morgan Cr., Cherry Cr., Ruby Cr., Wall Cr., and Johnny Gul. drainages. Light defoliation from budworm feeding was seen in these areas in the past few years, but no host tree mortality has resulted. Privately-owned DF stands south of Virginia City were also infested in 1953. (R.R. SCHULZ, D.R., 9/15/53) (*U256*)
Bitterroot	1927	Stevensville (North End)	800*	ES,GF	In the Big Cr. drainage. Increased damage; only young trees were infested. (T.J. DONICA, D.R., 11/28/27)(*U257*)
	1938	Stevensville	1,000	ES	In the Upper Burnt Fork Bitterroot R., in T.7N.,R.18W. Widespread, including ornamental trees in the (Bitterroot) Valley. (O.E. YORK, D.R., 12/2/38) (*U257*)
		West Fork	1,000	DF	Unknown insect caused defoliation of current season's needles; needles often were not completely consumed; some trees were killed (presumably budworm.--Authors). (S.H. LARSON, D.R., 11/12/38) (*U257*)
	1951	Sula	NR	DF	Heavy. Adventitious growth on host trees indicated prior infestations of several years' duration. (S.T. BILLINGS, D.R., West Fork R.D., Oct. 1951) (*U257*)
		West Fork	4,500	DF	Very severe and spreading. South side of Deer Cr. presumably infested for several years, as indicated by adventitious growth of host trees. Large groups of DF trees were attacked

(con. next page; for footnotes see end of table)

Table 4. (con.)

National Forest	Year	Ranger district	Infested acreage	Host tree species	Pertinent infestation conditions, reporter, and references
Bitterroot	1951	West Fork (con.)			by the Douglas-fir beetle in this area. New infestations of budworm were observed in 1951 on the north side of Deer Cr. and in the Thunder Mt., Alta, and Woods Cr. areas. (S.T. BILLINGS, D.R., Oct. 1951) (*U257*)
	1953	Sula	NR	DF,ES,GF,SF	Very light to heavy throughout the District. The 12,000 acres of infested timber type aerially sprayed with DDT during July 9 and 10, 1952 (Guide Cr., Jennings Camp Cr., and E.Fk. Bitterroot R.) were reinfested this year. (V.O. HAMRE, D.R., 9/18/53) (*U257*)
		West Fork	NR	DF	Decreased; almost all DF type was infested in the Overwhich Cr. area. Spread this year to Taylor Cr. and along the west side of the W.Fk. Bitterroot R. to Coal Cr. (S.T. BILLINGS, D.R., 11/18/53) (*U257*)
Custer	1935	Beartooth (Stillwater)	NR	ES	Very light; static. Only scattered trees in the Stillwater R. and W.Fk. Rosebud Cr. drainages were infested. (R.F. COONEY, D.R., 7/17/35) (*U262*)
	1937	Beartooth (Stillwater)	NR	ES	Same conditions as in 1935, but in T.6S.,R.14-15E. in the Stillwater R. drainage. No tree mortality was observed. (C.S. WALKER, D.R., 11/8/37) (*U262*)
	1939	Beartooth (Stillwater)	NR	ES	Endemic; in the Stillwater R. drainage (T.6-7S.,R.14E.) R.G. GALLUP, D.R., 11/21/39) (*U262*)
	1940	Beartooth (Stillwater)	40	ES	Static in the area reported on in 1939. (R.G. GALLUP, D.R., 11/6/40) (*U262*)
Deerlodge	1945	Boulder	480	DF	In the N.Fk. Little Boulder R. drainage in T.5N.,R.5W. (W.K. BRAY, Acting D.R., 11/19/45) (*U263*)
		Whitehall	NR	DF	In Bigfoot Park, Secs. 6-7, 18-19; T.4N.,R.4W.; Secs. 1-2, 11-14, 23-24; T.4N.; R.5W. Widespread. Some tip and branch killing was seen on occasional trees, but no host tree killing. (R. E. DICKINSON, D.R., 11/16/45) (*U263*)
	1946	Boulder	NR	DF	In the Elkhorn Unit, Little Boulder R., N.Fk. Boulder R., Galena Gul., and Hadley Park areas in T.5-6N.,R.2-4W. Light throughout but with increased defoliation and spread westward. (A.J. ARTHURS, D.R., 11/4/46) (*U263*)
		Whitehall	NR	DF	In the Bigfoot Park, Pony Canyon, Whitetail Cr., Bull Mts., and Hells Canyon areas. Increased and spread southwestward. (R.E. DICKINSON, D.R., 9/10/46) (*U263*)
	1947	Whitehall	NR	DF,ES	Light throughout most of the District, but severe in the State Cr., Beaver Cr., and Hay Canyon areas where up to 50% of the host trees in patches up to 200 acres in size were completely defoliated but alive. (G.F. ROSKIE, D.R., 11/20/47) (*U263*)
	1948	Boulder	NR	DF	All of the Elkhorn Unit and Little Boulder R. drainage were infested. Did not spread. Moth populations were markedly smaller. (R.E. LOCKHART, D.R., 11/3/48) (*U263*)
		Whitehall	NR	ES	Endemic in the S. Boulder R. drainage of the Tobacco Root Mts. and in Hells Canyon. Defoliation was light. (C.L. HAGEDORN, Asst. D.R., 11/10/48) (*U263*)
	1949	Boulder	NR	DF	In the Elkhorn Cr., Dry Cr., Muskrat Cr., and Little Boulder R. drainages in T.5N., R.4-5W., T.6N., R.2-3W. Virtually all DF trees in the District were infested, with topkilling noted in some of them. The moth population did not increase over that in 1948 except in localized areas. (R.E. LOCKHART, D.R., 11/14/49) (*U263*)

(con. next page; for footnotes see end of table)

Table 4. (con.)

National Forest	Year	Ranger district	Infested acreage	Host tree species	Pertinent infestation conditions, reporter, and references
Deerlodge	1949	Whitehall	15,000	DF	In the Bigfoot Basin and Lower Whitetail Park in T.3-4N., R.4-5W. Continued from previous years, mainly on scattered host trees in Site VI DF. Some tree mortality was noted. Light infestation occurred in DF from Homestake Pass to Hells Canyon. (F.H. BLACKMER, D.R., 11/14/49) (*U263*)
	1953	Boulder	2,400	DF	All infested host stands in the Elkhorn Cr., Dry Cr., and Little Boulder R. areas were aerially sprayed with DDT in July. (R.E. LOCKHART, D.R., 9/25/53) (*U263*)
		Deerlodge	NR	DF,ES	Covered all DF types from the spread of the last two years. Defoliation was less severe this year in the Douglas Cr. and Dunkelburg Cr. drainages. (J.L. ROGERS, D.R., 9/26/53) (*U263*)
		Philipsburg	20,000	DF	Increased in severity during the past 2 years in host stands in T.6-9N., R.13-14W. Defoliation was heavy this year in privately-owned timberlands west of Philipsburg. Host types in Rock Cr. were not infested. (F.E. WILLIAMS, D.R., 9/28/53) (*U263*)
		Whitehall			Still in evidence in the Bigfoot Basin and Lower Whitetail Park (T.3-4N.,R.4-5W.) aerially sprayed with DDT in July 1953. Defoliation was currently severe in Hells Canyon with a probable loss of infested trees. Spread on the Pipestone Bench (T.2-3N.,R.6W.) and in the Bull Mts. (T.3N.,R.3W.) (G.R. WOLSTAD, D.R., 10/5/53) (*U263*)
Flathead	1933	Coram (Elk Park)	NR	GF	Deep Cr. area; T.29N.,R.17W. Caterpillars were found on one tree only; no defoliation found anywhere in the District. (A.C. CAMPBELL, D.R., 11/16/33) (*U264*) "The spruce budworm infestation reported by Ranger Campbell is new to the Flathead. Campbell came...from the Selway (National Forest, Idaho) and should be able to identify the spruce budworm damage without question. It would seem probable, therefore, that his report is correct." (K. WOLFE, For. Supv., 11/29/33) (*U264*)
	1942	Spotted Bear	1,200*	ES,SF	Gorge Cr. area, T.23N., R.16W. New; no tree mortality; believed to be spreading southwestward up Gorge Cr. (J.N. ROOT, D.R., 11/27/42) (*U264*)
	1943	Big Prairie	6,000*	DF,LPP,ES,WL	Big Salmon Cr. drainage, T.20-21N.,R.14-15W.; approximately 50% of the trees of each host species were infested. H.THOL, D.R., 10/9/43) (*U264*)
		Spotted Bear	1,200	ES,SF	Same as in 1942. (J.N. ROOT, D.R., 11/23/43) (*U264*)
	1944	Big Prairie	1[illegible],000	DF,LPP,ES,WL	In the Big and Little Salmon Rivers and Gordon Cr. drainages, T.19-22N.,R.14-15W. Epidemic status exists in the Gordon Cr. drainage where as many as 75% of the trees of various host species were infested in spots. (H.W. GODFREY, D.R., 11/30/44) (*U264*)
		Spotted Bear	1,200	ES	Abated this year in the Gorge Cr. drainage; now endemic. (L.J. ANDERSON, D.R., 10/30/44) (*U264*)
	1945	Big Prairie	30,000	DF,WL,ES,SF, LPP	Throughout host stands in the main drainage of the S.Fk. Flathead R. from Gordon Cr. to Little Salmon Park. Mostly endemic with smaller host trees defoliated more heavily. (H.W. GODFREY D.R., 12/7/45) (*U264*)
		Spotted Bear	4,000	ES,SF,DF,LPP	Approximately 3,000 acres of host types were newly infested this year in the Helen Cr. and Damnation Cr. drainages (T.22-23N.,R.14W.); defoliation heavy. The older infestation in Gordon Cr. continued to decline. (C. SHAW, Acting D.R., 11/3/45) (*U264*)
	1946	Big Prairie	60,000	ES,DF	Continuous throughout host stands in the main drainage of the S.Fk. Flathead R. from Babcock Cr. and Young Cr. to the Little Salmon R. (T.20-21N.,R.13-14W.). An aerial survey of infested areas was made by J. C. EVENDEN, Entomol., U.S. Dep. Agric., Bur. Entomol. and Plant Quar., Coeur d'Alene, Idaho, and reported by him on 9/5/46. (R. T. CLONINGER, D.R., 11/22/46) (*U264*)

(con. next page; for footnotes see end of table)

Table 4. (con.)

National Forest	Year	Ranger district	Infested acreage	Host tree species	Pertinent infestation conditions, reporter, and references
Flathead	1946	Coram	NR	NR	Small, scattered patches of infestation were noticed throughout the District. No tree mortality was observed. (B.A. BEALEY, D.R., 11/12/46) (*U264*)
		Swan Lake	NR	NR	Isolated defoliation was noted throughout the District, but the infestation did not increase. (V.H. EASTMAN, D.R., 11/13/46) (*U264*)
	1947	Big Prairie	NR	ES,DF	Now present in all host stands throughout the District. Approximately 10% of all host trees under 6 inches d.b.h. were dead this year. Extent and intensity of infestations increased, but observed moth populations decreased in 1947. (R.T. CLONINGER, D.R., 11/12/47) (*U264*)
		Condon	NR	DF	Throughout the west slope of the Swan Range from Holland L. to Goat Cr. (T.19-22N.,R.16W.). Infestation is fairly old with newer infestations in the northernmost parts of the general infested area. New infestations noted in 1947. Host tree mortality from older infestations was heavy in isolated spots. (C.E. STILLWELL, D.R., 11/12/47) (*U264*)
		Spotted Bear	6,000	ES,SF,DF,LPP	Infestations reported in the Gorge Cr. drainage for the past 6 years were spreading. Host stands in the Helen Cr., Damnation Cr., and Snow Cr. drainages were badly infested, with some mortality among the younger host trees. Light infestations spread to stands in the White R. and the upper Spotted Bear R. areas and north along the S.Fk. Flathead R. to Spotted Bear Mt. in T.25N.,R.15W. (C. SHAW, Acting D.R., 11/14/47) (*U264*)
	1948	Big Prairie	NR	DF,ES	Observed throughout all DF-WL types. Host stands in the Danaher Cr. and Young Cr. drainages were newly infested. *Seemingly, stands on south- and west-facing slopes have suffered the greatest defoliation in most infested areas, with resultant killing of up to 100% of DF seedlings and saplings in many groups covering up to 2 acres in size. It is estimated that 15% of the mature DF trees have died from cumulative defoliation. ES trees have been lightly defoliated thus far in the outbreak.* (R.C. GARDNER, D.R., 12/1/48) (*U264*)
		Condon	NR	DF	Confined to upper parts of the west slope of the Swan Range. *This area probably was first infested by budworms invading through Smith Cr. Pass from severe infestations in the S.Fk. Flathead R. drainage.* (R.C. GARDNER, D.R., 12/1/48) (*U264*)
		Spotted Bear	6,000	ES,SF,DF,LPP	Decreased in the Gorge Cr., Helen Cr., Damnation Cr., and Snow Cr. areas, with about 10% of all of the host trees dead from cumulative defoliation. Now endemic in the White R., Spotted Bear R., and Spotted Bear Mt. areas. New infestations were noted this year on 2,000 acres on Green Mt. (T.25N.,R.14W.), with about 80% of the fir 50% defoliated. A few host trees were infested at the Spotted Bear R.S. (C. SHAW, D.R., 11/9/48) (*U264*)
		Swan Lake	NR	NR	Infestations very sparse. (V.H. EASTMAN, D.R.,11/9/48)(*U264*)
	1949	Big Prairie	50,000	DF,SF,ES,GF	All host types within the District have become infested, *with death of young age class trees amounting to as much as 100% on many of the drier sites; cumulative killing of mature trees is heavy on south-facing slopes. SF trees appear to be the most severely defoliated of the several host species. More timber has been killed or damaged from budworm feeding on the District in the past 7 years than from all known fires. The fire hazard will be very great and trail maintenance costs will increase in budworm-damaged stands.* (G.A. MARYOTT, Forester, 11/23/49) (*U264*)
		Condon	30,000*	DF	All DF timber types east of the Swan R. now have become infested. The first infestation west of the Swan R. was found this year in Sec. 23,T.21N.,R.17W. (R.C. GARDNER, D.R., 11/30/49) (*U264*)

(con. next page; for footnotes see end of table)

Table 4. (con.)

National Forest	Year	Ranger district	Infested acreage	Host tree species	Pertinent infestation conditions, reporter, and references
Flathead	1949	Spotted Bear	40,000	ES,DF,SF	All host types now infested except those in the upper 20 miles of the S.Fk. Flathead R. drainage. Infestations have steadily increased in severity and extent toward the east and north during the past few years. Many dead trees were observed in 1945-infested areas. All commercial host types in the District appear doomed if the outbreak does not abate or is not controlled. (C. SHAW, D.R., 11/23/49) (*U264*)
	1950	Condon	30,000	DF,ES,GF	Static. Considerably more dead DF saplings were noted in infested areas than in 1949, particularly at lower elevations. Losses of ES saplings and poles were reported by P.C. JOHNSON (Entomol., U.S. Dep. Agric., Bur. Entomol. and Plant Quar., Coeur d'Alene, Idaho) to be great along the south shore of Holland L. (R.C. GARDNER, D.R.,11/22/50)(*U264*)
		Spotted Bear	40,000	ES,DF,SF	No active infestations observed. (C. SHAW, D.R., 11/6/50) (*U264*)
		Swan Lake	6,000*	GF,SF	Epidemic in the Goat Cr., S. Lost Cr., Woodward Cr. drainages and at Soup Cr. Flats and Whitetail Lookout Station, with mild defoliation of upper crowns of understory trees. Spreading northward. (V.H. EASTMAN, D.R., 11/15/50) (*U264*)
Gallatin (Absaroka)	1925	Big Timber (Deer Creek, all)	NR	NR	Observed throughout the District; appeared to be declining. (H. M. CRANE, D.R., 11/13/25) (*U255*)
		Gardiner (Park,all)	40	ES,DF	Terminated on Crevice Mt., Sec. 22,T.9S.,R.9E. Appeared to be an extension of recent infestations in Yellowstone National Park. (C.H. JOHNSON, D.R., 11/14/25) (*U255*)
			NR	DF,ES	Considerable damage to host timber developed from budworm infestations in the District in 1922, 1923, and 1924, possibly even prior to 1922, with DF the favored host. *These infestations are now arrested, possibly from the cold winters of 1923-24 and 1924-25 which may have killed hibernating budworm larvae.* Many defoliated trees may survive. (G.E. MARTIN, For. Supv., 11/23/25) (*U255*)
		Livingston (Yellowstone, N3/4)	NR	DF,ES	Infestations similar to those above were also reported in the Mill Cr. drainage during the period 1922-24. (G.E. MARTIN, For. Supv., 11/23/25) (*U255*)
	1926	Big Timber (Deer Cr., all)	NR	DF	Only occasional scattered infested trees were seen. (H.M. CRANE, D.R., 11/8/26) (*U255*)
Gallatin	1927	Bozeman (Bridger, all)	160*	DF	New and increasing in the Jackson Cr. drainage (Sec. 20, T.1S.,R.8E.) (L.E. EWAN, JR., D.R., 11/21/27) (*U265*)
		Livingston (Yellowstone, all)	1,000*	DF,ES	Fridley (Strickland) Cr. (Secs. 25-27, 34-36; T.5S.,R.7E.); increasing trend. (W.W. WETZEL, D.R., 11/4/27) (*U265*)
	1928	Bozeman (Bridger, all)	1,120*	DF	Decreased to endemic status on 160 acres in V Canyon (Secs. 31-32; T.1N.,R.6E.). *Discovered by settlers in August 1923, increased in extent and severity until 1926, then subsided.* Decreasing on 160 acres in Corbly Canyon (T.5-6N.,R.6E.); may not be budworm. On 640 acres in the Brackett Cr. and Stone Cr. areas (Secs. 4-5; T.1N.,R.7E.; Secs. 10-11;T.1S., R.7E.); may not be budworm. Decreasing on 160 acres in the Jackson Cr. drainage (Secs. 20-21;T.1S.,R.8E.). (Damage to trees in these four areas may have been caused by *Chermes cooleyi*.--Authors.) (L.E. EWAN, JR., D.R, 11/26/28) (*U265*)
		Livingston (Yellowstone, all)	1,000*	DF,ES	In the Fridley Cr. drainage (Secs. 25-27,34-36;T.5S.,R.7E.), 4 years old, increasing. (W.W. WETZEL, D.R.,10/4/28)(*U265*)

(con. next page; for footnotes see end of table)

Table 4. (con.)

National Forest	Year	Ranger district	Infested acreage	Host tree species	Pertinent infestation conditions, reporter, and references
Gallatin	1929	Livingston (Yellowstone, all)	1,000	DF,ES	Same area as above; decreasing. (W.W. WETZEL, D.R., 10/9/29) (*U265*)
	1930	(Yellowstone, all)	1,000	DF,ES	Same area as above; decreasing. (W.W. WETZEL, D.R., 10/1/30) (*U265*)
	1931	Livingston (Gallatin, all)	NR*	ES	(E.P. WHITE, D.R., 11/20/31) (*U265*)
		Livingston (Yellowstone, all)	1,000	DF,ES	Fridley Cr. area (see 1928 location); decreasing. (A. CRAMER, D.R., 11/17/31) (*U255*)
	1932	Livingston (Yellowstone, all)	1,000	DF,ES	Fridley Cr. area; decreasing. (A. CRAMER, D.R., 11/15/32) (*U255*)
Gallatin (Absaroka)	1932	Bozeman (Shields, W1/2)	NR	DF,SF	Common over most of the District. Host trees averaging 8 inches d.b.h. have been considerably damaged over a number of years. Infestations appear to be increasing. (C.V. RUBOTTOM, D.R., 11/10/32) (*U255*)
		Livingston (Shields, E1/2)	NR	DF,SF	Same as above. (C.V. RUBOTTOM, D.R., 11/10/32) (*U255*)
	1933	Bozeman (Shields, W1/2)	NR	DF,SF	Static. Infested trees averaging 4 to 8 inches d.b.h. were common throughout the District. Considerable timber has been killed, but values are small. Control measures are not justified. (C.V. RUBOTTOM, D.R., 11/6/33) (*U255*)
		Livingston (Shields, E1/2)	NR	DF,SF	Same as above. (C.V. RUBOTTOM, D.R., 11/6/33) (*U255*)
Gallatin		Livingston (Yellowstone, all)	1,000	DF,ES	Fridley Cr. (see 1928 location); static. *About 2% of the number of host trees infested have died since the infestation began in 1924.* Control believed to be impractical. (A. CRAMER, D.R., 11/21/33) (*U255*)
Gallatin (Absaroka)	1934-35, 1937-38	Bozeman (Shields, W1/2)	NR	DF,SF	Same as in 1933. (C.V. RUBOTTOM. D.R., 11/2/34, 11/13/35, 12/8/37, 11/16/38) (*U255*)
		Livingston (Shields, E1/2)	NR	DF,SF	Same as in 1933. (C.V. RUBOTTOM, D.R., 11/2/34, 11/13/35, 12/8/37, 11/16/38) (*U255*)
Gallatin	1941	Bozeman (Bridger, all)	20,000	DF,SF	First-year infestations were seen in the Brackett Cr., Fairy Lake Cr., Frazier Cr., and Bridger Cr. drainages on host saplings and trees up to 18 inches d.b.h. and larger. Some trees were severely defoliated, most only moderately so. *No current cones are being produced on infested trees; surmised that this may be related to budworm feeding. Many new cones are aborted on infested trees; although cone moths may have caused this.* DF is the favored host. The severest infestation was in the Brackett Cr. drainage in Secs. 31-32, T.2N.,R.7E., and in Secs. 25-26, T.2N.,R.6E. (L.E. EWAN, D.R., 11/15/41) (*U265*)
	1942	Bozeman (Bridger, all)	NR	DF,SF,ES	Spread over the entire District. *Either no cones were produced, or they were aborted, in areas of severest infestation. Crows were observed feeding on budworm "millers" (moths) in August on the north slope of Battle Ridge.* (L.E. EWAN, D.R., 11/17/42) (*U265*)

(con. next page; for footnotes see end of table)

Table 4. (con.)

National Forest	Year	Ranger district	Infested acreage	Host tree species	Pertinent infestation conditions, reporter, and references
Gallatin	1942	Hebgen Lake	NR	SF	In the Sheep Cr. drainage in Sec. 17, T.12S.,R.3E. Defoliation was observed and budworm feeding was suspected as the cause. (A.H. ABBOTT, For. Supv., 12/4/42) (*U265*)
	1943	Bozeman (Bridger, all)	NR	NR	*"Red belt" frost damage during the winter of 1942-43 is reported in August to have killed terminal buds and prevented growth of 1943 foliage on host trees in a budworm-infested area near SW1/4 Sec. 8, T.1N.,R.7E. Budworm populations appear to have been drastically reduced. No follow-up infestation by bark beetles was observed in the frost-weakened trees.* (B.A. ANDERSON, For. Supv., correspondence to the Regional Forester, 12/20/43) (*U265*)
	1944	Bozeman (Bridger all)	NR	DF,SF,ES	Host stands badly infested in former years throughout the District appeared to be recovering, although all host trees were dead in scattered areas of up to 40 acres in size in the Brackett Cr., Weasel Cr., Skunk Cr., and Cache Cr. drainages. Currently, infestations are subsiding in the Battle Ridge and Cache Cr. areas while increasing in severity in other areas, notably Secs. 10, 16, 28, 33, 34;T.1N.,R.7E in Secs. 30-32; T.1S.,R.8E.; and in Secs. 2, 11;T.3N.,R.6E. Defoliation in these latter areas is severe for the first time. Current infestations were generally severe in the District. (L.E. EWAN, D.R., 11/27/44) (*U265*)
		Bozeman (Bozeman, all)	NR	DF,ES	Static; infestations were present throughout the District. (A.J. KRAMIS, D.R., 11/23/44) (*U265*)
	1945	Bozeman (Bozeman, all)	NR	DF,SF,ES	All host stands were infested in the Bridger Mts. Unit and in Sec. 21 and Sec. 28; T.3S.,R.7E. of the Bozeman Unit. In the Bridger Mts. Unit, infestations were subsiding north of Olson Cr. and increasing in the White Cr., Stone Cr., Jackson Cr., Spring Cr., Fleshman Cr., and Perkins Cr. drainages. *Infestations in the Bozeman Unit are just beginning, principally on south-facing slopes.* (L.E. EWAN, D.R., 11/19/45) (*U265*)
	1946	Bozeman (Bozeman, all)	NR	DF,ES	Generally subsided, except in the Stone Cr. drainage in Secs. 10-12; T.1S.,R.7E., where an increasing trend was noted. (L.E. EWAN, D.R., 11/26/46) (*U265*)
	1947	Bozeman (Bozeman, all)	NR	DF,ES	No new infestations; previously infested stands appeared to be recovering. (L.E. EWAN, D.R., 11/17/47) (*U265*)
	1948	Bozeman (Bozeman, all)	30,000	DF	Increased, with moths very abundant during flight period in the Bridger Cr., Stone Cr., Spring Cr., and Jackson Cr. drainages. Infested acreages within the Forest were estimated to be 11,000 in T.1N.,R.7E., and 7,000 in T.1S., R.8E. An estimated 5,000 acres were infested outside but adjacent to the Forest. (E.D. WHITE, for L.E. EWAN, D.R., 11/10/48) (*U265*)
	1949	Bozeman (Bozeman, all)	NR	NR	Declined, with less defoliation apparent in stands in the Bridger Cr. and Jackson Cr. drainages. (J.C. URQUHART, For. Supv., memorandum to the Regional Forester, 10/28/49) (*U265*)
		Livingston (Yellowstone, N3/4)	NR	DF	Infestation in Sixmile Cr. was confirmed 10/28/49 by P.C. JOHNSON, Entomol., U.S. Dep. Agric., Bur. Entomol. and Plant Quar., Coeur d'Alene, Idaho. (J.C. URQUHART, For. Supv., memorandum to Regional Forester) (*U265*)

(con. next page; for footnotes see end of table)

Table 4. (con.)

National Forest	Year	Ranger district	Infested acreage	Host tree species	Pertinent infestation conditions, reporter, and references
Gallatin	1950	Livingston (Yellowstone, N3/4)	NR	NR	Declined throughout the Forest; very little activity observed. (J.C. URQUHART, For. Supv., memorandum to the Regional Forester, 11/28/50) (*U265*)
	1951	Bozeman (Bozeman, all)	NR	DF,SF,ES,LPP	Older infestations declined in the Bridger Cr., Stone Cr., Spring Cr., White Cr., and Jackson Cr. drainages. New infestations developed this year in the Lyman Cr. and Chum Cr. drainages (T.1S.,R.6E.) on the west slope of the Bridger Range and in the Rocky Canyon and Francham Mt. areas (T.2S.,R.7E.) south of U.S. Highway 10. (H.D. HALPIN, D.R., 10/9/51) (*U265*)
		Bozeman (Shields, W1/2)	NR	DF,SF,ES,LPP	Infestations were observed throughout the District, primarily in DF stands. Moths were seen to be abundant in the upper Willow Cr. drainage in T.1S.,R.8E. (F.B. HALLER, D.R., 10/8/51) (*U265*)
		Gardiner	600	DF	Beattie Gul. south to Stevens Cr. (T.9S.,R.8E.), mostly within Yellowstone National Park, and west to the Mol Herron Cr. drainage (T.9S.,R.7E.), mostly on private lands. (D.E. NIVEN, For. Aid, 10/8/51) (*U265*)
		Livingston (Shields, E1/2)	NR	DF,SF,ES,LPP	Infestations observed throughout the District, primarily in DF stands. (F.B. HALLER, D.R., 10/8/51) (*U265*)
	1953	Bozeman (Bozeman, all)	NR	DF	Declined in severity in the Ross Cr., N. Cottonwood Cr., Bridger Cr., Spring Cr., Stone Cr., and Jackson Cr. drainages (T.1N.,R.6E.; T.1-2S.,R.6-8E.) (H.D. HALPIN, D.R., 11/17/53) (*U265*)
		Bozeman (Shields, W1/2)	NR	DF	Decreased to endemic status along the east slope of the Bridger Range from Willow Cr. north to Sixteen Mile Cr. (F.B. HALLER, D.R., 11/13/53) (*U265*)
		Gardiner	1,500	DF	Decreased in severity in areas reported in 1951 and in Bassett Cr. (T.8-9S.,R.7-9E.). (J. MORRISON, D.R., 11/4/53) (*U265*)
		Livingston (Yellowstone, all)	NR	NR	Less active than in 1952. See report for 1949. (D.W. NELSON, D.R., 11/10/53) (*U265*)
Helena	1925	Townsend (Deep Cr., all)	5,000*	DF	Approximately 75% of DF trees under 18 inches d.b.h. were infested in the Cabin Gulch and Russell Fk. Deep Cr. drainages in Secs. 10-14, 23, 24; T.7N., R.4E.; and in Secs. 7, 17-19; T.7N.,R.5E. Infested DF timber in one 40-acre tract in Sec. 12 above was a "total loss." Infestations are increasing. (E.V. WELTON, D.R , 9/30/25) (*U266*)
	1926	Townsend (Deep Cr., all)	7,000	DF	Increased in the Cabin Gulch area in Secs. 10-14, 23-26; T.7N.,R.4E.; and in Secs. 7,18-19;T.7N.,R.5E. Hundreds of DF seedlings and saplings have been killed; 40- to 80-year-old DF trees are dying and will not survive another year of defoliation in numerous areas up to 40 acres in size. *Younger trees are more seriously infested.* (E.V. WELTON, D.R., 11/13/26) (*U266*)
	1927	Townsend (Deep Cr., all)	7,500*	DF	In the Cabin Gulch, Russel Fk., Deep Cr., and the south side Deep Cr. areas in Secs. 10-14, 23-26; T.7N.,R.4E.; and in Secs. 7,18-20;T.7N.,R.5E. Host trees up to the 30- to 40-year-old age classes comprised most of those infested. *Defoliation and tree mortality was the most severe on south-east-facing slopes, with DF timber a "total loss" on areas up to 40 acres in size.* (E.V. WELTON, D.R., 11/11/27) (*U266*)

(con. next page; for footnotes see end of table)

Table 4. (con.)

National Forest	Year	Ranger district	Infested acreage	Host tree species	Pertinent infestation conditions, reporter, and references
Helena	1928	Townsend (Deep Cr., all)	8,500	DF	Generally in the same areas as in 1927. (E.V. WELTON, D.R., 11/10/28) (*U266*)
	1929	Townsend (Deep Cr., all)	9,000*	DF	In the 1927- and 1928-infested areas and 80 acres additional in Sec. 25; T.6N.,R.4E. infested in 1929. (E.V. WELTON, D.R., 11/6/29) (*U266*)
	1930	Canyon Ferry (Duck Cr., N3/4)	8,000*	DF	First-season infestations observed to be increasing in the Dry Range, Avalanche Butte, and Duck Cr. areas in Secs. 13-15,21-24;T.12N.,R.3E.;Secs. 18-19,30-31; T.12N., R.2E.; Secs. 25-26;T.12N.,R.1E.; and Secs. 24-26,35-36;T.9N.,R.3E. (C.F. MARTINEAU, JR., D.R., 11/14/30) (*U266*)
		Townsend (Deep Cr., all)	12,000*	DF	In the Deep Cr., Sulphur Bar Cr., Dry Cr., and Haw Gulch drainages (Secs. 10-15,22-27;T.7N.,R.5E.; Secs. 8,17,30; T.6N., R.5E.; Secs. 25,36;T.6N.,R.4E.; and Secs. 22,27,34; T.5N.,R.4E. Some budworm defoliation may be seen anywhere in the District. *Infestations of spruce spider mite were noted on DF trees in several small areas in Secs. 3,24; T.5N.,R.4E.; and in Sec. 25; T.6N.,R.4E.* (E.V. WELTON, D.R., 11/14/30) (*U266*) *Spider mites and their eggs attracted large numbers of yellow jacket wasps and ants. Ants worked industriously on mite-infested trees while yellow jackets hovered about. It is supposed that the mites were used to "fill the larders" of the ants and yellow jackets.* (L.C. HURTT, For. Supv., memorandum to Regional Forester, 11/25/30) (*U266*)
	1931	Canyon Ferry (Duck Cr., N3/4)	10,000	DF	Very light throughout the District. (C.F. MARTINEAU, JR., D.R., 11/16/31) (*U266*)
		Townsend (Deep Cr.; Crow Cr.; Duck Cr., S1/4)	14,000*	DF	In the 1930-infested areas and in the Rocky Canyon drainage in Secs. 10-15,22-27;T.7N.,R.4E.;Secs. 17-20,30;T.7N.,R.5E.; Secs. 8,17,30;T.6N.,R.5E.; Secs. 25,36;T.6N.,R.4E.; and Secs. 22,27,29,34;T.5N.,R.4E. Infestations slightly increased in extent but with less damage. *Spider mite infestations static.* (E.V. WELTON, D.R., Deep Cr.-Crow Cr. R.D., 11/2/31) (*U266*)
	1932	Canyon Ferry (Duck Cr., N3/4)	NR	DF	Very light throughout the District; no trees killed since 1930. (C.F. MARTINEAU, JR., 11/14/32) (*U266*)
		Townsend (Townsend, all; Duck Cr.,S1/4)	14,000	DF	Same as in 1931. (E.V. WELTON, D.R., Townsend R.D., 11/11/32; C.F. MARTINEAU, JR., D.R., Duck Cr. R.D., 11/14/32) (*U266*)
	1933	Townsend (Townsend, all)	12,100	DF	In the Cabin Gulch, Deep Cr., Dry Cr., and Sixteen Mile Cr. drainages in parts of T.5-7N.,R.3-5E. "After an attack of several seasons, areas of 40 to 60 acres of seedlings, saplings, and young growth have been totally destroyed on the Cabin Gulch drainage. Direction of spread has been to the south....During the present season the attack seems to have subsided, but groups of trees within the affected areas and on the outside borders of all previously reported areas, and on areas where the attack was made two and three years ago, were attacked again this year. Infested trees occur in groups, and usually a 100% stand of young growth will be killed. *It seems that successive attacks from year to year will usually prove fatal to at least 60% of the trees up to 10 inches in diameter. Four to 8 years is usually the time*

(con. next page; for footnotes see end of table)

Table 4. (con.)

National Forest	Year	Ranger district	Infested acreage	Host tree species	Pertinent infestation conditions, reporter, and references
Helena	1933	Townsend (Townsend, all) (con.)			*it takes to kill the larger-sized trees.* In the spring affected areas usually show up grey, but along in July these affected areas begin to turn reddish in color. A few small areas of new attacks were noticed during the 1933 season, and the attack within the old affected areas did not seem to be so extensive this year as in previous years." (E.V. WELTON, D.R., 11/16/33) (*U266*)
	1934	Townsend (Townsend, all)	12,100	DF	Same as in 1933; decreasing severity. *After the second or third year of attack, host timber acquires a grayish color.* (E.V. WELTON, D.R., 11/7/34) (*U266*)
	1935	Townsend (Townsend, all)	13,000*	DF	Same as in 1934; slight increase in severity. No large amounts of timber are being killed. (E.V. WELTON, D.R., 11/8/35) (*U266*)
	1936	Townsend (Townsend, all)	13,000	DF	Decreased with no spreading in parts of the Big Belt Mts. within T.7N.,R.4-5E.;T.6N.,R.4-5E.; and T.5N.,R.4E. Only seedlings and a few saplings were killed this year. (E.V. WELTON, D.R., 11/10/36) (*U266*)
	1937	Townsend	13,000	DF	In the Big Belt Mts., as above; continued in previously infested areas with some tree killing. (E.V. WELTON, D.R., 11/8/37) (*U266*)
	1938	Townsend	13,000	DF	Increased in severity, with a definite brownish cast to the timbered landscape throughout most of the Big Belt Mts. Division of the District. (E.E. LUER, Asst. D.R., 11/14/38) (*U266*)
	1939	Townsend	13,000	DF	Continued; most prevalent in the Deep Cr. and Cabin Gulch drainages. No great amount of new tree killing. (C.W. WETTERSTROM, Acting D.R., 11/10/38) (*U266*)
	1940	Townsend	13,000	DF	Continued; most prevalent in the Cabin Gulch, Deep Cr., and Hay Cr. drainages. No large areas of new tree killing developed. Most of the dead timber from previous infestations is in Sec. 25; T.6N.,R.4E.; and Secs. 4,8,9,19-21; T.6N.,R.5E. Most of this timber has been dead for several years. (E. E. LUER, D.R., 11/13/40) (*U266*)
	1941	Townsend	15,000	DF	Continued; mostly in DF type in the Hay Cr. and Deep Cr. drainages and surrounding Grassy Mtn. in T.6-8N.,R.4-5E. (E. E. LUER, D.R., 11/8/41) (*U266*)
	1942	Townsend	20,000	DF	Increased in severity and extent; noted this year in the Kentucky Gulch and Thomas Gulch drainages near Benton Guard Station. Trees up to 24 inches d.b.h. and larger have been killed from repeated defoliation on the east slope of Grassy Mt. in Sec. 33; T.7N.,R.5E., and in Sec. 4; T.6N.,R.5E. (E. E. LUER, D.R., 11/12/42) (*U266*)
	1943	Townsend	NR	DF	The infestation, now 10 years old, increased most rapidly in the last 2 years and now covers almost all the DF type in the Big Belt Mts. Unit of the District, as well as in large sections of the Slim Sam Cr., Crow Cr., and Beaver Cr. drainages in the Elkhorn Mts. Unit. *No evidence was found of any bark beetle infestations in budworm-damaged stands. "Areas of dead timber due to 'red belt' winter kill (of DF trees) should not later be confused with this (budworm) infestation, as it now appears that about 80% of the timber in the 'red belts' will die."* (C.A. MacGREGOR, D.R., 11/15/43) (*U266*). (Massive amounts of dead timber from the 1942-43 winter kill were still to be seen in 1968, some fallen, but much of it still standing, on the divide between Greyson Cr. and Dry Cr. near the west boundary of the Forest.--Authors.)
	1944	Townsend	NR	DF	Continued throughout the District. *"Contrary to expectations, the epidemic condition did not slacken last year following the winter kill (of DF trees) of 1942-43."* (C.A. MacGREGOR, D.R., 7/17/45) (*U266*)

(con. next page; for footnotes see end of table)

Table 4. (con.)

National Forest	Year	Ranger district	Infested acreage	Host tree species	Pertinent infestation conditions, reporter, and references
Helena	1945	Canyon Ferry	65,000*	DF	First-year epidemics were observed in the Candle Mt., Trout Cr., Magpie Cr., and the upper Avalanche Cr., Whites Gulch, and Cement Gulch areas. Continuing endemic infestations were seen in the lower parts of Whites Gulch and Avalanche Cr. drainages, in other parts of the Trout Cr. and Magpie Cr. drainages, and in the Willow Cr. and east side of Beaver Cr. drainages. Large flights of moths were observed in July coming from a southerly direction. Infestations generally were increasing in extent and severity, but no host tree mortality has been observed as yet. (J. R. JANNSON, D.R., 11/14/45) (*U266*)
		Helena	600	DF	In the Park Gulch and Skelly Gulch areas (T.11N.,R.5W.) outside of the Forest. *A flight of budworm moths was noted August 5, 1945 traveling in a northwesterly direction over a strip of land approximately 1/4 mile wide and 4 miles long.* Most of the DF reproduction in this strip was attacked (probably in the previous year, or years--Authors). (V.J. EDWARDS, D.R., 11/13/45) (*U266*)
		Townsend	NR	DF	Continued unchanged throughout the District except for a slight increase in extent. The largest area of budworm-killed timber since the start of the outbreak on this District was that reported in 1940 on the eastern slope of Grassy Mt. *In areas of "red belt", or winter kill (of DF trees) in 1942-43, it is difficult to determine the cause of the death of the trees (i.e., whether by budworm defoliation, climatic conditions, or a combination of these or other causal factors.*--Authors). (C.A. MacGREGOR, D.R., 11/25/45) (*U266*)
	1946	Canyon Ferry	75,000	DF	Infested areas continued as listed in 1945 and added areas of infested trees were seen in the Vermont Gulch drainage this year. Host stands in parts of Whites Gulch and Hellgate Gulch are now almost completely defoliated from continuing infestations of recent years. *Some DF stands damaged by frost ("red belt", or winter kill) in the winter of 1942-43 have been attacked by budworms. The trees in these stands ar now completely defoliated and appear to be dying.* The increase in the general epidemic was not as rapid this year as it was in 1945. Not many DF stands in the District remain uninfested. (J.R. JANNSON, D.R., 11/19/46) (*U266*)
		Helena	600	DF	In the Park Gulch and Skelly Gulch drainages; spread this year into the headwaters of Little Prickly Pear Cr. in T.11N.,R.5E. Heaviest damage is to DF reproduction. (E.P. WHITE, D.R., 11/26/46) (*U266*)
		Townsend	NR	DF	Epidemic throughout all host stands in the District. No new budworm-caused tree mortality observed. (C.A. MacGREGOR, D.R., 11/7/46) (*U266*)
	1947	Canyon Ferry	75,000	DF	All DF stands in the District are now infested. Infestation is generally declining. *About 90% of the host trees are now dead in stands damaged in the winter kill of 1942-43 and subsequently infested by the budworm. An example of this are stands in the vicinity of old Whites City in Whites Gulch.* (L. R. OLSEN, Forester, 11/21/47) (*U266*) Extensive infestations were encountered throughout the Dry Range and in numerous areas along the eastern timber fringe of the Big Belt Mts. Defoliation was severe in places, amounting to "almost total devastation of very large areas" of host forests. (C.C. STRONG, Chief, Div. of Information and Education, Regional Office, Missoula, Mont., memorandum of 8/12/47 to J.C. EVENDEN, Entomologist, Bur. of Entomol. and Plant Quar., Coeur d'Alene, Idaho) (*U266*)
		Helena	NR	DF	Throughout all DF stands on the District. (E.P. WHITE, D.R., 11/20/47) (*U266*)
		Townsend	NR	DF	Same as in 1946; decreasing trend. (A. D. MOIR, For. Supv., memorandum to the Regional Forester, 11/28/47) (*U266*)

(con. next page; for footnotes see end of table)

Table 4. (con.)

National Forest	Year	Ranger district	Infested acreage	Host tree species	Pertinent infestation conditions, reporter, and references
Helena	1948	Canyon Ferry	75,000	DF	In Whites Gulch, Avalance Cr., east side Beaver Cr., Magpie Cr., Trout Cr., Vermont Gulch, and Willow Cr. drainages; static. (J.L. ROGERS, Forester, 11/2/48) (*U266*)
		Helena	NR	DF,SF,ES	Throughout the District, with attacks heaviest east of the Continental Divide. SF trees were heavily defoliated. (E.P. WHITE, D.R., 11/22/48) (*U266*)
	1949	Canyon Ferry	80,000	DF	Throughout all host stands on the District southeast of Soup Cr. along the west slope of the Big Belt Mts.; also in the Vermont Gulch and Beaver Cr. drainages along the east slope of the Big Belts. The most heavily damaged stands were in the Whites Gulch, Avalanche Cr., Bilk Gulch, upper Magpie Cr., and upper Trout Cr. drainages. Infestations static. *Many trees repeatedly defoliated are now dying or are being attacked and killed by the Douglas-fir beetle in parts of the upper Trout Cr., Whites Gulch, and Spring Gulch (where 40% of the DF trees marked for sawlog cutting during the past six months were dead and an additional 40% are currently infested), upper Willow Cr., Cottonwood Gulch, and Sweats Gulch drainages.* (J.L. ROGERS, Asst. D.R., 10/24/49) (*U266*)
		Helena	NR	DF,SF	Throughout all host types on the District; heaviest in the Little Prickly Pear Cr. drainage from Austin Station (N.P.R.R.) to Granite Butte (T.11N., R.5-6W.;T.12N.,R.6-7W.; and T.13N.,R.7W.). Some smaller trees were dying from successive defoliation. Lightest infestations were noted in the Little Blackfoot R. drainage west of the Continental Divide. (E.P. WHITE, D.R., 10/27/49) (*U266*)
		Townsend	NR	DF	Throughout all DF stands on the District, but principally centered in the Big Belt Mts. in areas totalling 30,000 acres of National Forest and 6,000 acres of privately-owned timberlands within the Forest. Infested areas, by priority of damage, include the following drainages: Ray Cr.-Deep Cr., 15,000 acres; Benton Gulch, 6,000 acres; Faulkner Cr.-Hay Cr. (east slope of Grassy Mt.), 6,000 acres; Dry Cr.-Greyson Cr., 5,600 acres; Gurnett Cr., 900 acres. (G.N. Engler, Acting D.R., 10/21/49) (*U266*) Budworm control measures are believed imperative at the earliest possible date to stop infestations now in all DF stands east of the Continental Divide and in some to the west; also possibly those of the Douglas-fir beetle. (A.D. MOIR, For. Supv., 10/31/49) (*U266*)
	1951	Canyon Ferry	NR	NR	Intensity declined throughout the District. A budworm survey this year by R.E. DENTON (Entomologist, U.S. Dep. Agric., Bur. Entomol. and Plant Quar., Coeur d'Alene, Idaho) was cited. (W.R. FALLIS, D.R., by C.M. HOFFERBER, 12/2/51) (*U266*)
		Lincoln	5,000	DF	In the Canyon Cr., Tarhead Cr., and Trout Cr. drainages, south to Marsh Cr. along the east slope of the Continental Divide (T.14N.,R.6W.). Infestations began in 1948, increasing in area each year. Infestations in the Beaver Cr. and Stonewall Cr. drainages have been dormant for the last two years. (J.W. VENRICK, D.R., 10/11/51) (*U266*)
		Townsend	48,000	DF	All host type within the District has become infested in recent years. The heaviest infestations reported were in 1946 and 1947. A heavy moth flight this year was described in a special report on 8/20/51. A budworm survey this year by R.E. DENTON was cited. (V.J. EDWARDS, D.R., 10/1/51) (*U266*) All DF stands throughout the Forest area have become infested, but none severe enough to cause tree mortality. Infestations appeared to be declining, except those increasing in the Marysville, Nevada Cr., and Colorado Mt. areas. Control was not recommended because of the high cost of successfully treating the vast infestations. *Attacks of the Douglas-fir beetle have almost vanished from the Forest, but surveillance will be continued to detect any increase in them in trees weakened by budworm defoliation.* (A.D. MOIR, For. Supv., 10/12/51) (*U266*)

(con. next page; for footnotes see end of table)

Table 4. (con.)

National Forest	Year	Ranger district	Infested acreage	Host tree species	Pertinent infestation conditions, reporter, and references
Helena	1953	Canyon Ferry	200,000	DF	Continued throughout all host type on the District; most severely in all timbered drainages of the Missouri R. Mortality of young DF trees was very heavy on 800 acres near the head of the Soup Cr. and Bear Trap Cr. drainages; other tree mortality was noticed in DF stands in the Avalanche Cr., Cave Gulch, and Hellgate Gulch drainages. Other heavily infested stands this year were observed in the Moore Cr., Gates of the Mountains Wild Area, Trail Gulch, and Fuller Mt. localities and in the Horse Gulch area in the Smith R. country. (W.R. FALLIS, D.R., 10/9/53) (*U266*)
		Lincoln	NR	DF	In all DF stands throughout the District; particularly evident in the Lincoln Valley south of Montana Highway 20 and in the vicinity of Flesher Pass, Poorman Cr., and Nevada Cr. New, light infestations were noted in the Keep Cool Cr. and Sucker Cr. drainages. (L.R. OLSEN, D.R., 10/14/53) (*U266*)
		Townsend	48,000	DF	Continued throughout all DF stands on the District. The moth flight appeared lighter this year. (V.J. EDWARDS, D.R., 10/6/53) (*U266*)
Kootenai	1939	Fortine	NR	ES	In the Grave Cr., Foundation Cr., Stahl Cr., and Clarence Cr. drainages; a widespread but light infestation exists in all age classes of host trees. (S.H. LARSON, D.R., 11/24/39) (*U268*)
Lewis & Clark (Absaroka)	1926		NR	NR	*"The spruce budworm, whose activities have been so much in evidence on the Forest in former years, has almost entirely disappeared."* (E.H. MYRICK, For. Supv., 11/26/26) (*U255*)
	1932	Mussellshell (Shields, N1/3)	NR	DF,SF	Infested host trees were common throughout the District, mainly in T.5-7N.,R.9-10E.; infestations increased. Defoliation over a number of years has caused considerable damage to host trees. (C.V. RUBOTTOM, D.R., 11/10/32) (*U255*)
	1933	Musselshell (Shields, N1/3)	NR	DF,SF	Continued in all host types. Considerable timber has been killed, but values are small. No control was recommended. (C.V. RUBOTTOM, D.R., 11/6/33) (*U255*)
	1934	Musselshell (Shields, N1/3)	NR	DF,SF	Same as in 1933. (C.V. RUBOTTOM, D.R., 11/2/34) (*U255*)
	1935	Musselshell (Shields, N1/3)	NR	DF,SF	Concentrated in some localities, but generally declining. (C.V. RUBOTTOM, D.R., 11/13/35) (*U255*)
	1937	Musselshell (Shields, N1/3)	NR	ES	In host seedlings and trees up to 8 inches d.b.h. throughout the District. (C.V. RUBOTTOM, D.R., 12/8/37) (*U255*)
	1938	Musselshell (Shields, N1/3)	NR	ES	Same as in 1937, with infested trees being distorted but not killed. (C.V. RUBOTTOM, D.R., 11/16/38) (*U255*)
Lewis & Clark	1938	Teton	NR	ES	Possibly 25% of the ES saplings throughout the District were infested. Infestations increased this year over those of previous years. No host trees were killed in 1938. (G.H. DUVENDACK, D.R., 11/16/38) (*269*)
	1944	White Sulphur	NR	ES	In the Smith R. drainage (T.11-12N.,R.5-7E.). Infested trees were quite noticeable, but appeared only slightly injured. (C.W. JACKSON, Asst. For. Supv., 11/15/44)(*U269*)
	1945	White Sulphur	1,100	DF	In the Tenderfoot Cr. drainage (T.13-14N.,R.5E.), 1,000 acres, and in the Miller Gulch and upper Newlin Cr. drainages, 100 acres. Insect specimens collected by the District Ranger were subsequently identified as the spruce budworm. (B.L. HURWITZ, D.R., 11/11/45) (*U269*)

(con. next page; for footnotes see end of table)

Table 4. (con.)

National Forest	Year	Ranger district	Infested acreage	Host tree species	Pertinent infestation conditions, reporter, and references
Lewis & Clark	1946	Musselshell	NR	DF	"This (unknown) defoliating insect (probably budworm--Authors) is found throughout DF stands on the District, and, while the actual damage does not appear great at this time, it may be a future threat to our DF (stands)..." (G.R. ROSKIE, D.R., 11/13/46) (*U269*)
	1947	Belt Creek, Judith, & White Sulphur	NR	DF	Annual attacks are continuing in DF stands throughout the Little Belt Mts. and the Crazy Mts. on these three Districts, but with little evidence of immediate host tree mortality. (F.O. LEFTWICH, For. Supv., memorandum to the Regional Forester, 11/28/47) (*U269*)
	1948	Musselshell	NR	DF	Same as in 1947. (J.S. FORSMAN, D.R., 11/10/48) (*U269*)
	1949	White Sulphur	NR	DF	Wide spread throughout the District; not decreasing, and with no host tree mortality as yet. (B.L. HURWITZ, D.R., by F.T. BAILEY, 11/18/49) (*U269*)
	1950	Musselshell			Now infesting more than 60% of all host types. The peak of the infestation was reached in 1949 and it is now declining. (M.O. WATKINS, Acting For. Supv., 8/3/50) (*U269*)
					Throughout DF stands in the Castle Mts. and the Spring Cr. area of the Little Belt Mts.; declined in severity. (J.S. FORSMAN, D.R., 11/20/50) (*U269*)
		Sun River	6,000	DF,SF	In the Willow Cr. and Ford Cr. drainages (T.19-20N.,R.8-9W.). Most host trees at lower elevations and bordering the Sun R. plains were attacked. (M.O. WATKINS, Acting For. Supv., 8/3/50) (*U269*)
					Throughout the foothill DF stands and in the Loaf Cr. drainage. (D.C. MORRISON, D.R., 11/14/50) (*U269*)
		Teton	NR	DF	In the host type scattered throughout the foothills of the Rocky Mts. (J. F. HINMAN, D.R., 11/15/50) (*U269*)
		White Sulphur	NR	DF	Widely scattered throughout the District, but declining in severity. (G.A. MARHT, D.R., 11/8/50) (*U269*)
	1951	Musselshell	NR	DF	Rebuilding rapidly; heavy (defoliation) in 1951 in all DF stands in the Castle Mts. and Little Belt Mts. Spread this year to DF stands in the Crazy Mts. (J.S. FORSMAN, D.R., 10/2/51) (*U269*)
		White Sulphur	5	DF	In the Miller Gulch drainage (T.11N.,R.7E.) in a few scattered trees. (G. HOLMES, ACTING D.R., 10/6/51) (*U269*)
	1953	Musselshell	NR	DF	Declined in severity in areas infested in 1952 in the Castle Mts., Little Belt Mts., northwestern part of the Crazy Mts., and the Spring Cr. drainage. (J.A. FORSMAN, D.R., 9/18/53) (*U269*)
		White Sulphur	NR	DF	Nearly all DF stands on the District were infested to some degree. Severe defoliation with accompanying host tree mortality was noted in Secs. 13,24; T.11N.,R.6E. and in Secs. 18-20; T.11N.,R.7E. (G.A. MARHT, D.R., 9/18/51) (*U269*)
Lolo	1930	Superior (Quartz, all)	200	SF,WL,ES	In the W.Fk. Fish Cr. drainage. (G.H. HANKINSON, D.R., 11/15/30) (*U270*)
	1938	Seeley Lake	NR	ES	In the Clearwater R. and tributary drainages; only very slight host mortality was observed in the 5- to 20-year age class trees.(W.K. SAMSEL,L, D.R., 11/11/38) (*U270*)
	1939	Seeley Lake	NR	ES	Same as in 1938. (W.K. SAMSELL, D.R., 11/10/39) (*U270*)

(con. next page; for footnotes see end of table)

Table 4. (con.)

National Forest	Year	Ranger district	Infested acreage	Host tree species	Pertinent infestation conditions, reporter, and references
Lolo	1940	Seeley Lake	NR	ES	Same as in 1938. (W.K. SAMSELL, D.R., 11/4/40) *(U270)*
	1941	Seeley Lake	NR	ES	Apparently terminated with no noticeable host tree damage. (W.K. SAMSELL, D.R., 11/14/41) *(U270)*
	1946	Seeley Lake	70,000*	DF,ES,SF,LPP	Concurrent infestations of the hemlock looper and the budworm (latter insect's role not defined.--Authors) defoliated seedlings and saplings in small groups in the lower parts of the Placid Cr., Deer Cr., Marshall Cr., Colt Cr., and Morrell Cr. drainages. No tree mortality was reported. (H.W. GODFREY, D.R., 11/21/46) *(U270)*
	1947	Seeley Lake	75,000*	DF,ES,SF,LPP	Same as in 1946. (H.W. GODFREY, D.R., 11/26/47) *(U270)*
	1948	Bonita	NR	DF	In the Harvey Cr., Eightmile, and N.Fk. Willow Cr. drainages, but without severe defoliation. (A.B. GUNDERSON, Acting For. Supv. 11/12/48) *(U270)*
		Seeley Lake	75,000*	DF,ES,SF,LPP	Same as in 1946. (H.W. GODFREY, D.R., 11/1/48) *(U270)*
	1949	Bonita	NR	DF	Subsided in the Harvey Cr. drainage, but newly observed in Rock Cr. (E.H. MYRICK, For. Supv., memorandum to the Regional Forester, 12/1/49) *(U270)*
		Seeley Lake	80,000	DF,ES,SF,LPP	Endemic, with few host trees defoliated. (H.W. GODFREY, D.R., 11/21/49) *(U270)*
	1950	Bonita	NR	DF	Host trees were considerably defoliated in parts of the Harvey Cr., Rock Cr., and N.Fk. Willow Cr. drainages. (W.K. SAMSELL, D.R., 11/16/50) *(U270)*
		Seeley Lake	80,000*	DF	Endemic, with host trees only lightly defoliated and none killed in the same areas reported as infested in 1946. (H.W. GODFREY, D.R., by H.C. ROWLAND, 11/9/50) *(U270)*
	1951	Bonita	25,000	DF	Moving westward, now in the Tyler Cr. drainage (1950-infested areas presumably infested in 1951.--Authors). (W.L. SAMSELL, D.R., 10/16/51) *(U270)*
		Seeley Lake	NR	WL,DF,ES,SF	Same as in 1950, endemic or with a decreasing trend. (H.W. GODFREY, D.R., 10/10/51) *(U270)*

[1]Parenthesized names are those of former National Forests now part of the named Forest.

[2]Parenthesized names are those of former Ranger Districts now part of the named District.

[3]NR, not reported. Acreages followed by an asterisk (*) were outlined on maps that accompanied the report.

[4]Abbreviations for names of host tree species:

DF	Douglas-fir	LPP	Lodgepole pine
GF	Grand fir	PP	Ponderosa pine
SF	Subalpine fir	WWP	Western white pine
ES	Engelmann spruce	WH	Western hemlock
WL	Western larch	WR	Western redcedar

[5]Italicized statements are considered significant observations of the budworm's biology or behavior.

Table 5.--*Infestations by the western spruce budworm reported in Glacier and Yellowstone National Parks, 1922 through 1964*

National Park	Year	Ranger district	Infested acreage[1]	Host tree species[2]	Pertinent infestation conditions, reporter, and references[3]
					MONTANA
Glacier	1946	Hudson Bay	NR	ES	In the Waterton R. (T.37N.,R.18W.) and Belly R. (T.36N., R.17W.) drainages. (R.E. DENTON, Entomologist, Bur. Entomol. and Plant Quar., Coeur d'Alene, Idaho, Feb. 1952 (*U44*)
		West Lakes	NR	ES	In the Nyack Cr. and Thompson Cr. drainages (T.32N.,R.16W.) (R.E. DENTON, Feb. 1952) (*U44*)
	1947	Hudson Bay	NR	ES	A peak in the infestation was reached this year in the Waterton R. and Belly R. drainages. (R.E. DENTON, Feb. 1952) (*U44*)
		West Lakes	NR	ES	The epidemic reached its peak intensity in the Nyack Cr. and Thompson Cr. drainages. (R.E. DENTON, Feb. 1952) (*U44*)
	1948	West Lakes	8,500	ES	An assessment of cumulative host tree damage from continued defoliation from 1946 to 1948 revealed that it was light in the lower part of the Nyack Cr. drainage, moderate to severe in the middle and upper parts of the drainage, and very severe--100% host tree mortality on 1,000 acres--in the Thompson Cr. drainage. *The infestations in the two drainages during the period were among the most severe of those in the northern Rocky Mts. as well as being unique because the host was solely ES.* (R.E. DENTON, Feb. 1952) (*U44*)
	1950	West Lakes	NR	ES	Host trees in the Nyack Cr. basin were only lightly defoliated. (P.C. JOHNSON, Entomologist, Bur. Entomol. and Plant Quar., Coeur d'Alene, Idaho, 10/13/50) (*U110*)
	1951	West Lakes	NR	ES	No detailed description. (R.E. DENTON, Feb. 1952)(*U44*)
	1952	West Lakes	NR	ES	Declined; presumably terminated. (R.E. DENTON, Feb. 1952) (*U44*)
					WYOMING, MONTANA, AND IDAHO
Yellowstone	1922	North	NR	NR	*Believed to have been first noticed in the Blacktail Deer Cr. basin, Wyoming, in this year.* (J.C. EVENDEN, Entomologist, Bur. Entomol., Coeur 'Alene, Idaho, 10/5/23) (*U61*)
	1923		NR	DF,ES	Currently defoliated host trees--primarily DF--were evident from Mammoth Hot Springs to Tower Fall, in the Yellowstone R. canyon and side drainages from Blacktail Deer Cr. to Garnet and Crescent Hills, and in the Lamar R. canyon. Approximately 8% of the host trees were dead from budworm feeding (presumably in years prior to 1923--Authors). (J.C. EVENDEN, 10/5/23) (*U61*)
	1924	North	NR	DF,ES	The severity of host tree damage materially increased (presumably in the 1923-infested areas--Authors). Fifty percent of the infested DF trees were estimated to have been killed in the general area of the outbreak (see authors' comments in the 1923 report above--Authors). Defoliation was the most severe in pure stands of DF. *Thousands of DF trees weakened by budworm-caused defoliation were being attacked by the Douglas-fir beetle.* (J.C. EVENDEN, 10/22/24) (*U62*)
	1925	North	NR	DF,ES	No noticeable defoliation and no budworm eggs or young caterpillars were found in September 1925 in areas infested in 1923 and 1924. Many DF trees under 6 inches d.b.h. were dead from cumulative defoliation in previous years, while DF trees from 6 to 10 inches survived the defoliation and either resisted the first attacks of the Douglas-fir beetle or were not attractive hosts for the beetle. DF trees over 10 inches d.b.h. survived the defoliation very well but were attacked and killed by the beetle. (H.E. BURKE, Entomologist, Bur. Entomol., Stanford Univ., Calif., 3/16/26) (*U19*)

(con. next page; for footnotes see end of table)

Table 5. (con.)

National Park	Year	Ranger district	Infested acreage	Host tree species	Pertinent infestation conditions, reporter, and references
Yellowstone	1951	North	3,000	DF	In Reese Cr. and upper Stephens (Stevens) Cr. (T.9S.,R.8E., Prin. Mer. Mont.); very heavy defoliation of 1951 needles. Heavy budworm populations in August 1951 in vicinity of Mammoth Hot Springs, with night flying moths seen from there to Cooke City. (R.E. DENTON, Entomol., Bur. Entomol. and Plant Quar., Coeur d'Alene, Idaho, Feb. 1952) (*U44*)
	1952	North	15,720	DF	Electric Peak (Reese Cr., Stephens Cr.), 6,220 acres; Undine Falls, 2,330 acres; and Yellowstone R. (probably from Park boundary to Garnet Hill), 7,170 acres. Light defoliation in all areas. (R.E. DENTON, Entomol., Bur. Entomol. and Plant Quar., Coeur d'Alene, Idaho, 11/6/52) (*U45*)
	1953	North	22,000		Electric Peak-Sepulcher Mt., 6,800 acres; Yellowstone R., 15,200 acres. Defoliation light, 8,200 acres; moderate, 8,400 acres; and heavy, 5,400 acres. (R.E. DENTON, Entomol., For. Serv., Intermt. For. and Range Exp. Stn., Coeur d'Alene, Idaho, 6/3/54) (*U49*)
	1954	North	55,410*	DF	No report, acreage estimate derived from 1955 report, below.
	1955	North	60,840*	DF	Total of 55,410 acres of infested DF forest type aerially sprayed with DDT in July 1955 from northwest corner of Park throughout Yellowstone R. drainage to Tower Fall and Lamar Canyon. Scattered new light infestations totaling 5,430 acres near Druid Peak and Coyote Cr. (T.T. TERRELL, Entomol., For. Serv., Intermt. For. and Range Exp. Stn., Missoula, Mont., 1/11/56) (*U216*)
	1956	North	71,680*	DF	Defoliation averaged 10 percent on 55,410 acres of infested DF type aerially sprayed in July 1955. New infestations totaling 38,910 acres of DF type suffered moderate to heavy defoliation (mostly in Slough Cr., Soda Butte Cr., middle Lamar R., and Grand Canyon of the Yellowstone R.). (P.C. JOHNSON, Entomol., For. Serv., Intermt. For. and Range Exp. Stn., Missoula, Mont., 1/21/57) (*U118*)
	1957	North	71,680*	DF	Infested DF forest type totaling 67,800 acres aerially sprayed with DDT in Slough Cr., Soda Butte Cr., Lamar R., and Grand Canyon of the Yellowstone R.; also 3,880 acres in 1955-controlled unit to the west. Remainder of infested acreage lightly defoliated. (Files of the PEST CONTROL SECTION, Northern Region, For. Serv., Missoula, Mont.; T.T. TERRELL, Entomol., For. Serv., Intermt. For. and Range Exp. Stn., Missoula, 6/6/57; D. McCOMB and T.T. TERRELL, Entomols., For. Serv., Intermt. For. and Range Exp. Stn., Missoula, March 1958) (*U118,U181*)
	1958	North	71,680*	DF	Still evident throughout all previously infested areas. Heavy foliage discoloration from the spruce spider mite, *Oligonychus ununguis* (Jacobi), superimposed over that from budworm feeding in the drainages of Electric Cr., Reese Cr., and Stephens Cr. aerially sprayed with DDT in 1955 and those of Slough Cr., Soda Butte Cr., and Lamar R. sprayed with DDT in 1957. (T.T. TERRELL and D.G. FELLIN, Entomols., For. Serv., Intermt. For. and Range Exp. Stn., Missoula, March 1959) (*U237*)
	1959	North	71,680*	DF	Defoliation in 1959 at five sampling locations: 64, 55, 1, 0, 0 percent. (T.T. TERRELL, R.E. DENTON, and D.G. FELLIN, Entomols., For. Serv., Intermt. For. and Range Exp. Stn., Missoula, Mont., Jan. 1960) (*U235*)
	1960	North	71,680	DF	No details. (T.T. TERRELL, Entomol., For. Serv., Intermt. For. and Range Exp. Stn., Missoula, Mont., Feb. 1961)(*U223*)
	1961	North	10,750*	DF	Light over 98 percent of infested areas on Sepulcher Mt. and in Slough Cr., Soda Butte Cr., and Lamar R. drainages. (T.T. TERRELL, Entomol., For. Serv., Northern Region, Missoula, Mont., Apr. 1962) (*U226*)
	1962	North	5,940*	DF	All areas lightly defoliated; infested areas generally located as in 1961. (T.T. TERRELL, Entomol., For. Serv., Northern Region, Missoula, Mont., Jan. 1968) (*U225*)

(con. next page; for footnotes see end of table)

Table 5. (con.)

National Park	Year	Ranger district	Infested acreage	Host tree species	Pertinent infestation conditions, reporter, and references
Yellowstone	1963	North	1,050*	DF	Light or moderate defoliation in W.Fk. Electric Cr. and Chalcedony Cr. (T.T. TERRELL and K.W. KEEFE, Entomols., For. Serv., Northern Region, Missoula, Mont., Feb. 1964) (*U240*)
	1964	North	3,310*	DF	Mostly light defoliation, Electric Cr. and Sepulcher Mt. (T.T. TERRELL and K.W. KEEFE, Entomols., For. Serv., Northern Region, Missoula, Mont., Jan. 1965) (*U241*)

[1]NR, not reported. Acreages followed by an asterisk (*) were outlined on maps that accompanied the report.

[2]DF, Douglas-fir; SF, subalpine fir; ES, Engelmann spruce.

[3]Host tree species abbreviated as in column 5. Italicized statements are considered significant observations of the budworm's biology or behavior.

Table 6.--*Infestations by the western spruce budworm reported in National Forests of the Intermountain Region, 1922 through 1953*

National Forest[1]	Year	Infested acreage[2]	Host tree species[3]	Pertinent infestation conditions, reporter, and references
				IDAHO
Boise[4]	1922	NR	DF,GF,ES,WL	Defoliation very common throughout the Forest. (J.C. EVENDEN, Entomologist, U.S. Dep. Agric., Bur. Entomol., Coeur d'Alene, Idaho, 10/28/22) (*U59*)
	1923	NR	ES,DF,GF	Considerable defoliation but little mortality of named host trees. (R.H. RUTLEDGE, District (Regional) Forester, Ogden, Utah; letter to Chief Forester, Washington, D.C., 11/3/23[5]) (*U189*)
	1924	NR	NR	Defoliation appears to be decreasing. (R.H. RUTLEDGE, (Regional) Forester, Ogden, Utah; letter to Chief Forester, Washington, D.C., Oct. 1924[5]) (*U189*)
	1927	NR	SF,GF,DF	"The budworm is killing a lot of alpine fir, white fir, and in places considerable Douglas-fir." (R.H. RUTLEDGE, District (Regional) Forester, Ogden, Utah; letter to Chief Forester, Washington, D.C., 11/29/27[5]) (*U189*)
	1929	NR	NR	"...less active this year and appears to be subsiding." (R.H. RUTLEDGE, District (Regional) Forester, Ogden, Utah; letter to Chief Forester, Washington, D.C., 10/26/29[5]) (*U189*)
	1930	NR	NR	"The spruce budworm epidemic is apparently at an end." (R.H. RUTLEDGE, Regional Forester, Ogden, Utah; letter to Chief Forester, Washington, D.C., 10/8/30[5]) (*U200*)
	1931	NR	NR	Defoliation at a very low (endemic) stage. (R.H. RUTLEDGE, Regional Forester, Ogden, Utah; letter to Chief Forester, Washington, D.C., 12/2/31[5]) (*U201*)
	1950	NR	DF,GF,SF, ES,LPP	Moderate defoliation of DF in the Deadwood R. drainage; a budworm similar to the spruce budworm caused fairly heavy defoliation in LPP stands in the eastern part of the Forest. (L.W. ORR, Entomologist, U.S. Dep. Agric., Bur. Entomol. and Plant Quar., Ogden, Utah, March 1951) (*U185*)
	1951	NR	DF,SF	Moderate to severe defoliation in host stands in the Deadwood R., Beaver Cr., Lost Cr., Banner Cr., and Clear Cr. drainages. (L.W. ORR, Entomologist, U.S. Dep. Agric., Bur. Entomol. and Plant Quar., Ogden, Utah, Feb. 1952) (*U186*)
	1952	NR	DF,GF,SF,ES	Defoliation in host stands increased in severity and extent in the eastern half of the Forest; practically all new foliage of host trees was destroyed south and west of Atlanta, and in the Beaver Cr. and Deadwood R. drainages. (L.W. ORR, Entomologist, U.S. Dep. Agric., Bur. Entomol. and Plant Quar., Ogden, Utah, 9/9/52) (*U187*)
	1953	NR	DF,GF,SF,ES	Moderate to severe defoliation from smaller but better surviving larval populations; still no extensive killing of host stands, but many intermediate and suppressed host trees are dying or dead. (L.W. ORR, Entomologist, Intermt. For. and Range Exp. Stn., Ogden, Utah, April 1954) (*U188*)
Challis (Lemhi)	1923	NR	ES,DF,GF	Approaching epidemic status in the Lost Cr., Stanley Basin, and Cape Horn country. (R.H. RUTLEDGE, District (Regional) Forester, Ogden, Utah; letter to Chief Forester, Washington, D.C., 11/3/23[5]) (*U189*)
	1924	NR	NR	Lost Cr. (*U189*)
	1937	NR	ES	Prevalent in most host stands; very little defoliation and host tree growth is not retarded. (E.E. McKEE, FOREST Supv., Challis-Lemhi Natl. For., Challis, Idaho, 10/15/37) (*U189,U254*)
Payette[6] (Weiser, Idaho)	1922	NR	DF,GF,ES,WL	Defoliation observed in N.Fk. Payette R. and upper Little Salmon R. drainages. (J.C. EVENDEN, Entomologist, U.S. Dep. Agric., Bur. Entomol., Coeur d'Alene, Idaho, 10/28/22) (*U59, 35*)
	1923	NR	ES,DF,GF	Considerable defoliation but no mortality of host trees. (R.H. RUTLEDGE, District (Regional) Forester, Ogden, Utah; letter to Chief Forester, Washington, D.C., 11/3/23[5]) (*U189*)

(con. next page; for footnotes see end of table)

Table 6. (con.)

National Forest	Year	Infested acreage	Host tree species	Pertinent infestation conditions, reporter, and references
Payette[6] (Weiser, Idaho	1924	NR	NR	Defoliation appears to be decreasing. (R.H. RUTLEDGE, District (Regional) Forester, Ogden, Utah; letter to Chief Forester, Washington, D.C., Oct. 1924[5]) (*U189*)
	1927	NR	SF,GF,DF	"The budworm is killing a lot of alpine fir, white fir, and in places considerable Douglas-fir." (R.H. RUTLEDGE, District (Regional) Forester, Ogden, Utah; letter to Chief Forester, Washington, D.C., 11/29/27[5])(*U189*)
	1928	NR	GF,SF,DF	Much defoliation throughout host types on Ranger District #1 and in the Goodrich Cr., Dukes Cr., and Johnson Cr. drainages of Ranger District #2 (Weiser Natl. For.). In the latter District, GF has been entirely killed (GF stands?--Authors) and considerable DF has been seriously damaged. Pure stands of GF and DF will be wiped out unless the budworm is checked. (J. RAPHAEL, Forest Supv., Weiser Natl. For., McCall, Idaho, 10/15/28) (*U251*)
	1929	NR	DF,ES,GF,SF	Infestations appear to have subsided to current endemic status, but past infestations have completely defoliated some of the smaller GF and SF trees. Most of the trees damaged by past defoliation are recuperating. (S.C. SCRIBNER, Forest Supv., Idaho Natl. For., McCall, Idaho, 10/12/29) (*U252*)
				Defoliation continued in some localities; epidemic infestation probably exists in parts of the Bear R. Ranger District (Weiser Natl. For.), but infestations are less prevalent than those of several years ago over most of the Forest. (J. RAPHAEL, Forest Supv., Weiser Natl. For., Weiser, Idaho, 10/14/29) (*U251*)
	1930	NR	NR	Reported "still going." (*U189*)
Payette	1952	NR	DF,GF,SF,ES	Heavy defoliation near Riggins, with this area and infested areas on the Boise National Forest totaling 1 million acres of host forests. (L.W. ORR, Entomologist, U.S. Dep. Agric., Bur. Entomol. and Plant Quar., Ogden, Utah, 9/9/52) (*U187*)
	1953	NR	DF,GF,SF,ES	Moderate to severe defoliation (totaling 1/2 million acres of host forests on the Boise, Payette, and Salmon National Forests) with no extensive killing of host stands but with many intermediate and suppressed host trees dying or dead. The most severe host stand damage was observed in the Big Cr. drainage of the Idaho Primitive Area. Many infested stands on the Forest contain a high proportion of good quality grand fir. (L.W. ORR, Entomologist, Intermt. For. and Range Exp. Stn., Ogden, Utah, April 1954) (*U188*)
Salmon	1953	NR	DF,GF,SF,ES	Moderate to severe defoliation (totaling 1/2 million acres of host forests on the Boise, Payette, and Salmon National Forests) with no extensive killing of host stands but with many intermediate and suppressed host trees dying or dead. The most severe host stand damage was observed in the Big Cr. drainage of the Idaho Primitive Area. Many infested stands on the Forest contain a high proportion of good quality grand fir. (L.W. ORR, Entomologist, Intermt. For. and Range Exp. Stn., Ogden, Utah, April 1954) (*U188*)
Sawtooth	1924	NR	NR	No detailed information. (R.H. RUTLEDGE, District (Regional) Forester, Ogden, Utah; letter to Chief Forester, Washington, D.C., Oct. 1924[5]) (*U189*)
	1927	NR	DF,SF	No detailed information. (*U189*)
	1930	NR	NR	"The spruce budworm epidemic is apparently at an end" in the National Forests of western Idaho (Boise, Challis, Idaho (new Payette), Lemhi (Challis, Salmon), old Payette (Boise), Salmon, Sawtooth, and Weiser (new Payette)). (R.H. RUTLEDGE, Regional Forester, Ogden, Utah; letter to Chief Forester, Washington, D.C., 10/8/30[5]) (*U189*)
	1949	NR	DF,ES	Severe defoliation near Big Smoky Ranger Station. (*U189*)
	1950	NR	DF	Moderate defoliation in the Little Smoky Cr. drainage. (L.W. ORR, Entomologist, U.S. Dep. Agric., Bur. Entomol. and Plant Quar., Ogden, Utah, March 1951) (*U185*)

(con. next page; for footnotes see end of table)

Table 6. (con.)

National Forest	Year	Infested acreage	Host tree species	Pertinent infestation conditions, reporter, and references
Sawtooth	1951	NR	DF,SF	Defoliation much less severe than in 1950 in the Little Smoky Cr. drainage. (L.W. ORR, Entomologist, U.S. Dep. Agric., Bur. Entomol. and Plant Quar., Ogden, Utah, Feb. 1952) (*U186*)
	1952	NR	DF,SF,ES	Defoliation much reduced over that of the past two years. (L.W. ORR, Entomologist, U.S. Dep. Agric., Bur. Entomol. and Plant Quar., Ogden, Utah, 9/9/52) (*U187*)
	1953	NR	DF,SF,ES	Smaller but better surviving budworm populations noted in infested areas. (L.W. ORR, Entomologist, Intermt. For. and Range Exp. Stn., Ogden, Utah, April 1954) (*U188*)
Targhee	1927	NR	NR	Infestation reported; no details. (*U189*)
	1943	NR	NR	Infestation reported; no details. (*U189*)
	1944	NR	NR	Infestation reported; no details. (*U189*)
				WYOMING
Bridger (Wyoming)	1926	NR	SF,DF	Defoliation reported, no details. (R.H. RUTLEDGE, District (Regional) Forester, Ogden, Utah; letter to Chief Forester, Washington, D.C., 12/13/26[5]) (*U189*)
	1935	NR	NR	Small area on Greys R. infested. (R.H. RUTLEDGE, Regional Forester, Ogden, Utah; letter to Chief Forester, Washington, D.C., 11/9/35[5]) (*U189*)
Teton	1923	NR	NR	Infestation reported; no details. (*U189*)
	1924	NR	NR	Heavy defoliation, no details. (R.H. RUTLEDGE, District (Regional) Forester, Ogden, Utah; letter to Chief Forester, Washington, D.C., Oct. 1924[5]) (*U189*)
				UTAH
Cache	1927	NR	LPP	Budworm infesting LPP trees in Emigrant Cr. and Williams Cr. drainages (not substantiated--Authors). (R.H. RUTLEDGE, District (Regional) Forester, Ogden, Utah; letter to Chief Forester, Washington, D.C., 11/29/27[5]) (*U189*)
Uinta	1924	NR	NR	"Considerable spruce budworm." (R.H. RUTLEDGE, District (Regional) Forester, Ogden, Utah; letter to Chief Forester, Washington, D.C., Oct. 1924[5]) (*U189*)
	1925	15	LPP	In the Duchesne R. drainage. (*U189*)
Wasatch	1929	NR	SF	Defoliation of host trees near Timpanogos Cave. (*U189*)
				NEVADA
Humbolt	1931	NR	NR	Infestation reported; no details. (*U189*)
(Nevada)	1935	NR	NR	Infestation reported; no details. (*U189*)

[1]Parenthesized names are those of former National Forests now part of the named Forest.
[2]NR, not reported.
[3]Host tree species abbreviations:

DF	Douglas-fir	ES	Engelmann spruce
GF	Grand fir	WL	Western larch
SF	Subalpine fir	LPP	Lodgepole pine

[4]Includes the original Payette National Forest combined with the Boise National Forest on April 1, 1944.
[5]Permanently filed at the Federal Records Center, Denver, Colorado; for retrieval contact the Division of Timber Management, Forest Service, Federal Building, Ogden, Utah 84401.
[6]Present Payette National Forest created April 1, 1944, by consolidation of the former Idaho and Weiser National Forests.

Table 7.--*Estimated gross acreage of host forests visibly defoliated by the western spruce budworm within the Northern Region, by States, 1948 through 1971*

Year	Administrative unit[1]	Wash.	Idaho	Mont.	Total	References
1948	Glacier Natl. Park			8,500		
	Helena N.F.			261,560	270,060	*U107*
	Totals			270,060	270,060	
1949	Deerlodge N.F.			90,000		*U108*
	Helena N.F.			290,000		*U108*
	Gallatin N.F.			26,000		*U108*
	Nezperce N.F.		25,280			*U101*
	Totals		25,280	406,000	431,280	
1950	Clearwater N.F.		10,600			*U41*
	Deerlodge N.F.			100,000		*U109*
	Flathead N.F.			218,000		*U39,U40*
	Gallatin N.F.			26,000		*U93*
	Helena N.F.			290,000		*U93,U111*
	Lewis & Clark N.F.			50,000		*U93*
	Nezperce N.F.		12,480			*U38*
	Craig Mt. (private)		7,080			*U38*
	Glacier Natl. Park			5,000		*U93,U110*
	Totals		30,160	689,000	719,160	
1951	Bitterroot N.F.			12,000		*U44,U110*
	Clearwater N.F.		23,700			*U44,U45*
	Deerlodge N.F.			120,000		*U44,U114*
	Flathead N.F.			235,000		*U44,U45, U114*
	Gallatin N.F.			80,000		*U44,U45, U114*
	Helena N.F.			560,000		*U44,U45, U114*
	Lewis & Clark N.F.			100,000		*U44,U45, U114*
	Lolo N.F.			1,600		*U44,U45, U114*
	Nezperce N.F.		20,500			*U44,U45*
	Craig Mt. (private)		9,200			*U44,U45, U114*
	Garnet Range (BLM)			30,000		*U45*
	Glacier Natl. Park			1,000		*U44,U45, U112,U114*
	Yellowstone Natl. Park			[2] 3,000		*U44,U45, U114*
	Totals		53,400	1,142,600	1,196,000	

(con. next page; for footnotes see end of table)

Table 7. (con.)

Year	Administrative unit	Wash.	Idaho	Mont.	Total	References
1952	Beaverhead N.F.			17,560		U45
	Bitterroot N.F.			123,140		U45
	Clearwater N.F.		80,380			U45
	Deerlodge N.F.			297,480		U45
	Flathead N.F.			23,320		U45
	Gallatin N.F.			180,080		U45
	Helena N.F.			583,040		U45
	Lewis & Clark N.F.			194,790		U45
	Lolo N.F.			47,360		U45
	Nezperce N.F.		58,620			U45
	Craig Mt. (private)		129,440			U45
	Garnet Range (BLM)			162,120		U45
	Yellowstone Natl. Park			[2]15,720		U45
	Totals		268,440	1,644,610	1,913,050	
1953	Beaverhead N.F.			31,600		U47
	Bitterroot N.F.			140,300		U47
	Clearwater N.F.		80,400			U47
	Deerlodge N.F.			269,600		U47
	Flathead N.F.			59,900		U47
	Gallatin N.F.			304,500		U47
	Helena N.F.			565,500		U47
	Lewis & Clark N.F.			202,400		U47
	Lolo N.F.			48,400		U47
	Nezperce N.F.		42,600			U47
	Craig Mt. (private)		138,400			U47
	Garnet Range (BLM)			195,100		U47
	Yellowstone Natl. Park			[2]22,000		U47
	Totals		261,400	1,839,300	2,100,700	
1954	Beaverhead N.F.			110,850		U3
	Bitterroot N.F.			126,020		U3
	Clearwater N.F.		86,700			U3
	Deerlodge N.F.			278,000		U3
	Flathead N.F.			60,050		U3
	Gallatin N.F.			379,900		U3
	Helena N.F.			680,250		U3
	Lewis & Clark N.F.			66,600		U3
	Lolo N.F.			59,480		U3
	Nezperce N.F.		38,880			U3
	Craig Mt. (private)		171,500			U3
	Garnet Range (BLM)			126,100		U3
	Yellowstone Natl. Park			[2]55,410		U216
	Totals		297,080	1,942,660	2,239,740	

(con. next page; for footnotes see end of table)

Table 7. (con.)

Year	Administrative unit	Wash.	Idaho	Mont.	Total	References
1955	Beaverhead N.F.			372,890		*U180,U217*
	Bitterroot N.F.			179,510		*U180*
	Clearwater N.F.		101,910			*U180,U217*
	Deerlodge N.F.			490,470		*U180,U217*
	Flathead N.F.			870		*U180,U217*
	Gallatin N.F.			579,670		*U180*
	Helena N.F.			842,260		*U180,U217*
	Lewis & Clark N.F.			408,420		*U180,U217*
	Lolo N.F.			89,220		*U180,U217*
	Nezperce N.F.		70,790			*U180*
	Craig Mt. (private)		89,480			*U180,U217*
	Garnet Range (BLM)			186,320		*U180,U217*
	Yellowstone Natl. Park			[2]60,840		*U180*
	Totals		262,180	3,210,470	3,472,650	
1956	Beaverhead N.F.			506,140		*U180*
	Bitterroot N.F			298,200		*U180*
	Clearwater N.F.		119,370			*U180*
	Deerlodge N.F.			535,200		*U180*
	Flathead N.F.			2,500		*U180*
	Gallatin N.F.			936,700		*U180*
	Helena N.F.			900,430		*U180*
	Lewis & Clark N.F.			535,510		*U180*
	Lolo N.F.			69,800		*U180*
	Nezperce N.F.		83,700			*U180*
	Craig Mt. (private)		60,000			*U180*
	Garnet Range (BLM)			226,800		*U180*
	Yellowstone Natl. Park			[2]142,500		*U180*
	Totals		263,070	4,153,780	4,416,850	
1957					[3]4,663,850	*U181*
1958					[3]4,894,690	*U237*
1959					[3]4,894,690	*U235*
1960	Beaverhead N.F.			134,270		*U226*
	Bitterroot N.F.			281,160		*U226*
	Deerlodge N.F.			282,240		*U226*
	Gallatin N.F.			465,160		*U226*
	Helena N.F.			658,990		*U226*
	Lewis & Clark N.F.			464,040		*U226*
	Lolo N.F.			40,420		*U226*
	Craig Mt. (private)		89,480			*U226*
	Garnet Range (BLM)			203,610		*U226*
	Yellowstone Natl. Park			[2]10,750		*U226*
	Totals		89,480	2,540,640	2,630,120	

(con. next page; for footnotes see end of table)

Table 7. (con.)

Year	Administrative unit	Wash.	Idaho	Mont.	Total	References
1961	Beaverhead N.F.			85,440		*U228*
	Bitterroot N.F.			276,870		*U228*
	Deerlodge N.F.			305,870		*U228*
	Gallatin N.F.			411,960		*U228*
	Helena N.F.			752,140		*U228*
	Lewis & Clark N.F.			576,450		*U228*
	Lolo N.F.			136,880		*U228*
	Centennial Val. (BLM)			24,700		*U228*
	Craig Mt. (private)		3,220			*U228*
	Garnet Range (BLM)			238,090		*U228*
	Yellowstone Natl. Park			[2] 9,500		*U228*
	Totals		3,220	2,817,900	2,821,120	
1962	Beaverhead N.F.			55,600		*U228*
	Bitterroot N.F.			324,830		*U228*
	Deerlodge N.F.			308,180		*U228*
	Gallatin N.F.			385,440		*U228*
	Helena N.F.			831,610		*U228*
	Lewis & Clark N.F.			527,090		*U228*
	Lolo N.F.			171,590		*U228*
	Centennial Val. (BLM)			27,890		*U228*
	Craig Mt. (private)		1,030			*U228*
	Garnet Range (BLM)			256,760		*U228*
	Yellowstone Natl. Park			[2] 5,940		*U228*
	Totals		1,030	2,894,930	2,895,960	
1963	Beaverhead N.F.			70,250		*U240*
	Bitterroot N.F.		105,530	246,240		*U240*
	Custer N.F.			710		*U240*
	Deerlodge N.F.			158,650		*U240*
	Gallatin N.F.			291,290		*U240*
	Helena N.F.			441,170		*U240*
	Kaniksu N.F.	[4]10,200	940			*U240*
	Lewis & Clark N.F.			317,230		*U240*
	Lolo N.F.			125,880		*U240*
	Nezperce N.F.		6,500			*U240*
	Centennial Val. (BLM)			18,640		*U240*
	Craig Mt. (private)		1,700			*U240*
	Garnet Range (BLM)			225,320		*U240*
	Judith Mts. (BLM)			580		*U240*
	Yellowstone Natl. Park			[2] 1,050		*U240*
	Totals	10,200	114,670	1,897,010	2,021,880	

(con. next page; for footnotes see end of table)

Table 7. (con.)

Year	Administrative unit	Wash.	Idaho	Mont.	Total	References
1964	Beaverhead N.F.			116,260		*U241*
	Bitterroot N.F.		98,810	148,220		*U241*
	Colville N.F.	[4] 740				*U241*
	Custer N.F.			3,720		*U241*
	Deerlodge N.F.			99,310		*U241*
	Gallatin N.F.			254,380		*U241*
	Helena N.F.			546,780		*U241*
	Kaniksu N.F.	[4] 2,060				*U241*
	Lewis & Clark N.F.			389,450		*U241*
	Lolo N.F.			151,790		*U241*
	Nezperce N.F.		166,610			*U241*
	Centennial Val. (BLM)			14,170		*U241*
	Craig Mt. (private)		2,680			*U241*
	Garnet Range (BLM)			190,320		*U241*
	Judith Mts. (BLM)			3,780		*U241*
	Yellowstone Natl. Park			[2] 3,310		*U241*
	Totals	2,800	268,100	1,921,490	2,192,390	
1965	Beaverhead N.F.			87,520		Compiled[5]
	Bitterroot N.F.		166,400	300,000		do.
	Deerlodge N.F.			47,760		do.
	Helena N.F.			546,780		do.
	Gallatin N.F.			468,480		do.
	Lewis & Clark N.F.			617,270		do.
	Lolo N.F.			507,060		do.
	Nezperce N.F.		566,350			do.
	Judith Mts. (BLM)			4,020		do.
	Yellowstone Natl. Park			[2] 2,560		do.
	Totals		732,750	2,581,450	3,314,200	
1966	Beaverhead N.F.			51,660		Compiled[5]
	Bitterroot N.F.		219,150			do.
	Clearwater N.F.		33,870			do.
	Custer N.F.			9,170		do.
	Deerlodge N.F.			22,180		do.
	Helena N.F.			316,080		do.
	Lolo N.F.			345,320		do.
	Nezperce N.F.		571,400			do.
	Judith Mts. (BLM)			6,160		do.
	Sweetwater Hills (BLM)			44,560		do.
	Totals		824,420	795,130	1,619,550	

(con. next page; for footnotes see end of table)

Table 7. (con.)

Year	Administrative unit	Wash.	Idaho	Mont.	Total	References
1967	Beaverhead N.F.			19,360		Compiled[5]
	Bitterroot N.F.		23,120	180,770		do.
	Clearwater N.F.		127,250			do.
	Custer N.F.			6,080		do.
	Deerlodge N.F.			430		do.
	Flathead N.F.			5,390		do.
	Gallatin N.F.			54,820		do.
	Helena N.F.			316,080		do.
	Lewis & Clark N.F.			32,230		do.
	Lolo N.F.			1,142,020		do.
	Nezperce N.F.		592,020			do.
	Judith Mts. (BLM)			5,430		do.
	Yellowstone Natl. Park			[2]12,700		do.
	Totals		742,390	1,775,310	2,517,700	
1968	Beaverhead N.F.			11,500		56
	Bitterroot N.F.		152,820	242,080		56
	Clearwater N.F.		240,600			56
	Custer N.F.			50,400		56
	Deerlodge N.F.			58,800		56
	Flathead N.F.			27,760		56
	Gallatin N.F.			187,300		56
	Helena N.F.			465,960		56
	Lewis & Clark N.F.			157,100		56
	Lolo N.F.			1,419,710		56
	Nezperce N.F.		1,310,100			56
	Flathead Indian Res.			59,240		56
	Garnet Range (BLM)			164,460		56
	Judith Mts. (BLM)			7,910		56
	Yellowstone Natl. Park			[2]22,700		56
	Totals		1,703,520	2,874,920	4,578,440	
1969	Beaverhead N.F.			20,170		Computed[5]
	Bitterroot N.F.		162,500	221,170		do.
	Clearwater N.F.		294,140			do.
	Custer N.F.			11,310		do.
	Deerlodge N.F.			96,230		do.
	Flathead N.F.			119,370		do.
	Gallatin N.F.			58,750		do.
	Helena N.F.			374,530		do.
	Lewis & Clark N.F.			75,340		do.
	Lolo N.F.			1,554,560		do.
	Nezperce N.F.		1,008,380			do.
	St. Joe N.F.		15,510			do.
	Yellowstone Natl. Park			[2] 5,610		do.
	Totals		1,480,530	2,537,040	4,017,570	

(con. next page; for footnotes see end of table)

Table 7 (con.)

Year	Administrative unit	Wash.	Idaho	Mont.	Total	References
1970	Bitterroot N.F.		162,500	302,500		Computed[5]
	Clearwater N.F.		360,000			do.
	Deerlodge N.F.			204,800		do.
	Flathead N.F.			61,500		do.
	Helena N.F.			32,000		do.
	Lolo N.F.			1,042,000		do.
	Nezperce N.F.		1,300,000			do.
	St. Joe N.F.		28,000			do.
	Flathead Indian Res.			163,000		do.
	Yellowstone Natl. Park			[2] 2,000		do.
	Totals		1,850,500	1,807,800	3,658,300	
1971	Beaverhead N.F.			15,000		Computed[5]
	Bitterroot N.F.		2,500	172,500		*21*
	Clearwater N.F.		378,000			*21*
	Deerlodge N.F.			285,680		*21*
	Flathead N.F.			167,000		*21*
	Gallatin N.F.			15,260		*21*
	Helena N.F.			377,280		*21*
	Lolo N.F.			1,260,000		*21*
	Nezperce N.F.		1,337,000			*21*
	St. Joe N.F.		42,560			*21*
	Flathead Indian Res.			194,000		*21*
	Yellowstone Natl. Park			[2]46,080		*21*
	Totals		1,760,060	2,532,800	4,292,860	

[1]Includes lands of all ownerships within or adjacent to the unit.

[2]Includes some lands in Wyoming and Idaho.

[3]Regional acreage not itemized by States.

[4]Biological evaluation made and reported by the Pacific Northwest Region (Region 6), USDA Forest Service, Portland, Oregon.

[5]Compiled by the Intermountain Forest and Range Experiment Station from original survey maps furnished by the Northern Region.

Table 8.--*Estimated gross acreage of host forests visibly defoliated by the western spruce budworm within the Intermountain Region, by States, 1954 through 1971*[1]

Year	National Forest[2]	Idaho	Wyoming	Utah	Total	References
1954	Boise	514,000				*U99,U100*
	Payette	114,000				*U99,U101*
	Boise-Payette	372,000[3]				*U100*
	Totals	1,000,000			1,000,000	
1955	Boise	681,000				*U24,U100*
	Challis	8,000				*U24*
	Payette	358,000				*U24,U100*
	Salmon	128,000				*U24*
	Totals	1,175,000			1,175,000	
1956	Boise	308,970				*U25,U26*
	Challis	22,250				*U26*
	Payette	383,310				*U25,U26*
	Salmon	249,600				*U25,U26*
	Sawtooth	71,400				*U26*
	Targhee	92,010				*U25,U26*
	Totals	1,127,540			1,127,540	
1957	Boise	131,370				*U28*
	Challis	38,310				*U28*
	Payette	445,580				*U28*
	Salmon	340,010				*U28*
	Sawtooth	99,310				*U28*
	Targhee	118,360				*U28*
	Totals	1,172,940			1,172,940	
1958	Boise	33,700				*U29*
	Challis	103,500				*U29*
	Payette	14,850				*U29*
	Salmon	478,000				*U29*
	Sawtooth	140,300				*U29*
	Targhee	204,360				*U29*
	Totals	974,710			974,710	
1959	Payette	5,000				*U295*
	Salmon	165,000				*U295*
	Sawtooth	125,000				*U295*
	Targhee	204,000				*U295*
	Totals	499,000			499,000	

(con. next page; for footnotes see end of table)

Table 8. (con.)

Year	National Forest	Idaho	Wyoming	Utah	Total	References
1960	Challis	150,000				*U296*
	Salmon	115,000				*U296*
	Sawtooth	121,000				*U296*
	Targhee	130,500				*U296*
	Totals	516,500			516,500	
1961	Boise	35,500				*U291*
	Challis	358,000				*U291*
	Payette	34,500				*U291*
	Salmon	858,000				*U291*
	Sawtooth	13,000				*U291*
	Targhee	126,000				*U291*
	Totals	1,425,000			1,425,000	
1962	Boise	60,000				*U294*
	Challis	297,000				*U294*
	Payette	137,000				*U294*
	Salmon	929,000				*U294*
	Sawtooth	41,000				*U294*
	Targhee	177,000				*U294*
	Totals	1,641,000			1,641,000	
1963	Boise	56,160				*U292*
	Challis	241,120				*U292*
	Payette	173,920				*U292*
	Salmon	877,180				*U292*
	Sawtooth	60,160				*U292*
	Targhee	214,560				*U292*
	Totals	1,623,100			1,623,100	
1964	Boise	46,080[3]				*U293*
	Challis	619,460[3]				*U293*
	Fishlake			20,000		*U293*
	Payette	147,460[3]				*U293*
	Salmon	1,342,000				*U293*
	Sawtooth	54,000				*U293*
	Targhee	67,000[3]				*U293*
	Totals	2,276,000		20,000	2,296,000	

(con. next page; for footnotes see end of table)

Table 8. (con.)

Year	National Forest	Idaho	Wyoming	Utah	Total	References
1965	Boise	60,200				61
	Bridger		10,000			61
	Challis	401,300				61
	Fishlake			10,000		61
	Payette	216,800				61
	Salmon	709,900				61
	Sawtooth	9,000				61
	Targhee	97,900				61
	Totals	1,495,100	10,000	10,000	1,515,100	
1966	Boise	59,400				59
	Bridger		33,800			59
	Challis	169,100				59
	Payette	83,700				59
	Salmon	521,600				59
	Sawtooth	110,000				59
	Targhee	14,600				59
	Totals	958,400	33,800		992,200	
1967	Boise	28,900				60
	Bridger		51,800			60
	Caribou	100				60
	Challis	1,600				60
	Fishlake			100		60
	Payette	79,600				60
	Salmon	25,600				60
	Sawtooth	18,100				60
	Targhee	10,000				60
	Teton		2,900			60
	Totals	163,900	54,700	100	218,700	
1968	Ashley			400		2
	Boise	27,700				2
	Bridger		95,200			2
	Caribou	6,000				2
	Challis	33,300				2
	Payette	221,600				2
	Salmon	43,000				2
	Sawtooth	46,700				2
	Targhee	17,000				2
	Teton		14,600			2
	Totals	395,300	109,800	400	505,500	

(con. next page; for footnotes see end of table)

Table 8. (con.)

Year	National Forest	Idaho	Wyoming	Utah	Total	References
1969	Ashley			400		*62*
	Boise	31,000				*62*
	Bridger		72,800			*62*
	Caribou	500				*62*
	Challis	20,000				*62*
	Payette	362,200				*62*
	Salmon	47,700				*62*
	Targhee	1,800				*62*
	Teton		8,000			*62*
	Bryce Canyon Natl. Park			Reported		
	Totals	463,200	80,800	400	544,400	
1970	Ashley			120		*79*
	Boise	5,800				*79*
	Bridger		55,800			*79*
	Caribou	100				*79*
	Payette	220,900				*79*
	Targhee	12,400				*79*
	Teton		12,600			*79*
	Totals	239,200	68,400	120	307,720	
1971	Boise	17,200				*80*
	Bridger		25,200			*80*
	Caribou	100				*80*
	Payette	316,200				*80*
	Targhee	9,800				*80*
	Teton		5,400			*80*
	Totals	343,300	30,600		373,900	

[1]No data available prior to 1954.
[2]Includes lands of all ownerships within or adjacent to the National Forest.
[3]Estimated gross acreage of host forests lightly defoliated but not mapped.

Table 9.--*Numbers of references to host tree species in Ranger District reports*[1] *of outbreaks of western spruce budworm in National Forests in northern Idaho, Montana, 1925 through 1953*

Host species	Sole host in-- Idaho	Sole host in-- Montana	Host with other species in-- Idaho	Host with other species in-- Montana
Rocky Mountain Douglas-fir	8	89	80	142
Grand fir	9	1	108	5
Engelmann spruce	9	21	87	65
Subalpine fir	2	1	36	40
Western larch	1	0	8	4
Western white pine	0	0	2	0
Lodgepole pine	0	0	7	10
Ponderosa pine	0	0	1	0
Numbers of reports	137	182	137	182

[1]Host tree species did not necessarily occur together in the same infested stands.

Table 10.--*National Forest Ranger Districts in northern Idaho reporting infestations of western spruce budworm, 1922 through 1953*

Year	National Forest	Ranger districts						
1922	Kaniksu	Priest Lake						
1923	Kaniksu	Priest Lake						
1924	Clearwater	Powell						
	Coeur d'Alene	Kingston						
	Kaniksu	Priest Lake						
	Nezperce	Red River						
1925	Clearwater	Powell						
	Nezperce	Clearwater	Red River					
1926	Bitterroot	Magruder						
	Clearwater	Lochsa	Powell					
	Nezperce	Clearwater	Elk City	Moose Creek	Red River	Salmon River	Selway	Slate Creek
1927	Bitterroot	Magruder						
	Clearwater	Lochsa	Pierce	Powell				
	Nezperce	Clearwater	Elk City	Moose Creek	Red River	Selway	Slate Creek	
	St. Joe	Avery						
1928	Clearwater	Lochsa	Pierce	Powell				
	Coeur d'Alene	Kingston						
	Nezperce	Clearwater	Elk City	Moose Creek	Red River	Selway	Slate Creek	
	St. Joe	Avery						
1929	Clearwater	Canyon	Lochsa	Powell				
	Coeur d'Alene	Kingston						
	Nezperce	Clearwater	Elk City	Moose Creek	Red River	Selway		
1930	Bitterroot	Magruder						
	Clearwater	Lochsa	Pierce					
	Coeur d'Alene	Kingston						
	Nezperce	Clearwater	Moose Creek	Red River	Selway			
1931	Bitterroot	Magruder						
	Clearwater	Lochsa						
	Coeur d'Alene	Kingston						
	Nezperce	Clearwater	Moose Creek	Red River	Selway			
1932	Clearwater	Bungalow	Lochsa					
	Coeur d'Alene	Kingston						
	Nezperce	Clearwater	Moose Creek	Selway				
1933	Clearwater	Bungalow	Lochsa					
	Coeur d'Alene	Kingston						
	Nezperce	Clearwater	Moose Creek	Selway				
1934	Bitterroot	Magruder						
	Clearwater	Lochsa						
	Nezperce	Moose Creek	Selway					
1935	Bitterroot	Magruder						
	Nezperce	Clearwater	Selway					
1936	Nezperce	Selway						
1937	Nezperce	Clearwater	Selway					
1938	Nezperce	Clearwater						
1939	Nezperce	Clearwater						
1940	Nezperce	Clearwater						
1941	Kaniksu	Trout Creek						
	Nezperce	Clearwater						
1942	Nezperce	Clearwater						
1943	Nezperce	Clearwater						
1944	None reported							
1945	Nezperce	Salmon River						
1946	Clearwater	Powell						
	Nezperce	Salmon River						
1947	Clearwater	Powell						
	Nezperce	Salmon River						
1948	Clearwater	Powell						
	Nezperce	Salmon River						
1949	Clearwater	Powell						
	Nezperce	Salmon River						
1950	Clearwater	Powell						
	Nezperce	Salmon River						
1951	Clearwater	Powell						
	Nezperce	Salmon River						
1952	Clearwater	Powell						
	Nezperce	Salmon River						
1953	Clearwater	Powell						
	Nezperce	Salmon River						

Table 11.--*National Forest Ranger Districts in Montana reporting infestations of western spruce budworm, 1925 through 1953*

Year	National Forest	Ranger districts		
1925	Beaverhead	Sheridan	Wisdom	
	Gallatin	Big Timber	Gardiner	Livingston
	Helena	Townsend		
1926	Beaverhead	Sheridan		
	Gallatin	Big Timber		
	Helena	Townsend		
1927	Beaverhead	Madison		
	Bitterroot	Stevensville		
	Gallatin	Bozeman	Livingston	
	Helena	Townsend		
1928	Beaverhead	Madison		
	Gallatin	Bozeman	Livingston	
	Helena	Townsend		
1929	Beaverhead	Madison		
	Gallatin	Livingston		
	Helena	Townsend		
1930	Gallatin	Livingston		
	Helena	Townsend		
	Lolo	Superior		
1931	Beaverhead	Madison	Sheridan	
	Gallatin	Livingston		
	Helena	Canyon Ferry	Townsend	
1932	Gallatin	Bozeman	Livingston	
	Helena	Canyon Ferry	Townsend	
	Lewis & Clark	Musselshell		
1933	Flathead	Coram		
	Gallatin	Bozeman	Livingston	
	Helena	Townsend		
	Lewis & Clark	Musselshell		
1934	Gallatin	Bozeman	Livingston	
	Helena	Townsend		
	Lewis & Clark	Musselshell		
1935	Custer	Beartooth		
	Gallatin	Bozeman	Livingston	
	Helena	Townsend		
	Lewis & Clark	Musselshell		
1936	Helena	Townsend		
1937	Custer	Beartooth		
	Gallatin	Bozeman	Livingston	
	Helena	Townsend		
	Lewis & Clark	Musselshell		
1938	Bitterroot	Stevensville	West Fork	
	Gallatin	Bozeman	Livingston	
	Helena	Townsend		
	Lewis & Clark	Musselshell		
	Lolo	Seeley Lake		
1939	Custer	Beartooth		
	Helena	Townsend		
	Kootenai	Fortine		
	Lolo	Seeley Lake		
1940	Custer	Beartooth		
	Helena	Townsend		
	Lolo	Seeley Lake		

(con. next page)

Table 11.--(con.)

Year	National Forest	Ranger districts			
1941	Beaverhead	Madison			
	Gallatin	Bozeman			
	Helena	Townsend			
	Lolo	Seeley Lake			
1942	Flathead	Spotted Bear			
	Gallatin	Bozeman	Hebgen Lake		
	Helena	Townsend			
1943	Flathead	Big Prairie	Spotted Bear		
	Gallatin	Bozeman			
	Helena	Townsend			
1944	Flathead	Big Prairie	Spotted Bear		
	Gallatin	Bozeman			
	Helena	Townsend			
	Lewis & Clark	White Sulphur			
1945	Deerlodge	Boulder	Whitehall		
	Flathead	Big Prairie	Spotted Bear		
	Gallatin	Bozeman			
	Helena	Canyon Ferry	Helena	Townsend	
	Lewis & Clark	White Sulphur			
1946	Deerlodge	Boulder	Whitehall		
	Flathead	Big Prairie	Coram	Swan Lake	
	Gallatin	Bozeman			
	Helena	Townsend			
	Lewis & Clark	Musselshell			
	Lolo	Seeley Lake			
1947	Deerlodge	Whitehall			
	Flathead	Big Prairie	Condon	Spotted Bear	
	Gallatin	Bozeman			
	Helena	Canyon Ferry	Helena	Townsend	
	Lewis & Clark	Belt Creek	Judith	Musselshell	White Sulphur
	Lolo	Seeley Lake			
1948	Deerlodge	Boulder	Whitehall		
	Flathead	Big Prairie	Condon	Spotted Bear	Swan Lake
	Gallatin	Bozeman			
	Helena	Canyon Ferry	Helena		
	Lewis & Clark	Musselshell			
	Lolo	Bonita	Seeley Lake		
1949	Beaverhead	Lima			
	Deerlodge	Boulder	Whitehall		
	Flathead	Big Prairie	Condon	Spotted Bear	
	Gallatin	Bozeman	Livingston		
	Helena	Canyon Ferry	Helena	Townsend	
	Lewis & Clark	White Sulphur			
	Lolo	Bonita	Seeley Lake		
1950	Flathead	Condon	Spotted Bear	Swan Lake	
	Gallatin	Livingston			
	Lewis & Clark	Musselshell	Sun River	Teton	White Sulphur
	Lolo	Bonita	Seeley Lake		
1951	Beaverhead	Wisdom			
	Bitterroot	Sula	West Fork		
	Gallatin	Bozeman	Gardiner	Livingston	
	Helena	Canyon Ferry	Lincoln	Townsend	
	Lewis & Clark	Musselshell	White Sulphur		
	Lolo	Bonita	Seeley Lake		
1952[1]					
1953	Beaverhead	Madison			
	Bitterroot	Sula	West Fork		
	Deerlodge	Boulder	Deerlodge	Philipsburg	Whitehall
	Gallatin	Bozeman	Gardiner	Livingston	
	Helena	Canyon Ferry	Lincoln	Townsend	
	Lewis & Clark	Musselshell	White Sulphur		

[1]District Rangers' reports not made because of regionwide budworm surveys by entomologists of the Bureau of Entomology and Plant Quarantine, Coeur d'Alene, Idaho.

Table 12.--*Estimated gross acreages of host forests visibly defoliated annually by the western spruce budworm in the Northern and Intermountain Regions, 1948 through 1971*

Year	Northern Region				Intermountain Region				Grand total
	Northeast Washington	Northern Idaho	Montana	Total	Southern Idaho	Western Wyoming	Utah	Total	
1948			270,060	270,060					270,060
1949		25,280	406,000	431,280					431,280
1950		30,160	689,000	719,160					719,160
1951		53,400	1,142,600	1,196,000					1,196,000
1952		268,440	1,644,610	1,913,050	1,000,000			1,000,000	2,913,050
1953		261,400	1,839,300	2,100,700	500,000			500,000	2,600,700
1954		297,080	1,942,660	2,239,740	1,000,000			1,000,000	3,239,740
1955		262,180	3,210,470	3,497,650	1,175,000			1,175,000	4,647,650
1956		263,070	4,153,780	4,416,850	1,127,540			1,127,540	5,544,390
1957		([2])	([2])	4,663,850	1,172,940			1,172,940	5,836,790
1958		([2])	([2])	4,894,690	974,710			974,710	5,869,400
1959		([2])	([2])	4,894,690	499,000			499,000	5,393,690
1960		89,480	2,540,640	2,630,120	516,500			516,500	3,146,620
1961		3,220	2,817,810	2,821,030	1,425,000			1,425,000	4,246,030
1962		1,030	2,894,930	2,895,960	1,641,000			1,641,000	4,536,060
1963[1]	10,200	114,670	1,897,010	2,021,880	1,632,100			1,623,100	3,644,980
1964[1]	2,800	268,100	1,921,490	2,192,390	2,276,000		20,000	2,296,000	4,488,390
1965		732,750	2,581,450	3,314,200	1,495,100	10,000	10,000	1,515,100	4,829,300
1966		824,420	795,130	1,619,550	958,400	33,800		992,200	2,611,750
1967		742,390	1,775,310	2,517,700	163,900	54,700	100	218,700	2,736,400
1968		1,703,520	2,874,920	4,578,440	395,300	109,800	400	505,500	5,083,940
1969		1,480,530	2,537,040	4,017,570	463,200	80,800	400	544,400	4,561,970
1970		1,850,500	1,807,800	3,658,300	239,200	68,400	120	307,720	3,966,020
1971		1,760,060	2,532,800	4,292,860	343,300	30,600		373,900	4,666,760

[1]Surveys of budworm outbreaks performed by the Pacific Northwest Region (Region 6) at Portland, Oregon.
[2]Regional acreage not itemized by States.

Table 13.--*Major outbreak cycles of western spruce budworm in the Northern and Intermountain regions since 1926*

Outbreak cycle	Forest Service Region	State	Duration	Peak year	Management units[1]
			Years		
I	Northern	Idaho	1926-33	1930	Bitterroot, *Clearwater*, Coeur d' Alene, *Nezperce*, St. Joe National Forests
II	Northern	Montana	1945-65	1959	Beaverhead, *Bitterroot*, *Deerlodge*, Flathead, *Gallatin*, *Helena*, *Lewis and Clark*, Lolo National Forests *Garnet Range* area of the Bureau of Land Management Yellowstone National Park (also in Wyoming)
III	Intermountain	Idaho	1954-58	1955	*Boise*, Challis, *Payette*, *Salmon*, Sawtooth, Targhee National Forests
IV	Intermountain	Idaho	1961-66	1964	*Challis*, *Payette*, *Salmon*, Sawtooth, Targhee National Forests
V	Northern	Montana	1967-	--	*Bitterroot*, Deerlodge, Flathead, *Gallatin*, *Helena*, Lewis and Clark, *Lolo* National Forests Garnet Range area of the Bureau of Land Management Flathead Indian Reservation
		Idaho	1967-	--	Bitterroot, *Clearwater*, *Nezperce* National Forests

[1]Based on annual Regional infested acreages (tables 4-8); units having 100,000 or more infested acres for at least 3 years of the cycle are italicized.

Table 14.--*Size and variation of populations of western spruce budworm by life stages and sampling units, 1950 through 1965*

Sampling unit	Year	Tree sp.[1]	Number of units: Minimum	Maximum	Average	Location	Reference
Eggs per egg mass	1959	DF			42.0	Montana	*U224*
	1960	DF			40.8		
Egg masses per 1,000 in^2 of foliage	1959	WF	5.6	31.8	14.5	S. Oregon/N. Calif.	*15*
	1960	WF	1.3	12.7	6.9		
	1961	WF	.2	26.9	6.6		
	1962	WF	.2	16.7	6.2		
	1963	WF	0	2.3	.8		
	1964	DF			15.0	Colorado	*72*
	1965	DF			15.0		
	1962	DF	2.0	28.0	14.5	S. Idaho	*U294*
		DF	3.0	32.0	3.7		*U294*
	1963	DF	1.1	25.2	9.6		*U292*
		DF	.6	10.2	5.5		*U292*
	1964	DF	4.2	36.7	14.4		*U293*
		DF	3.5	10.6	7.6		
	1958	DF	0	20.5	8.2	Montana	*U238*
	1959	DF	0	36.6	10.4		*U223*
	1960	DF	0	11.0	3.6		
Instar II budworm per 100 in^2 bole bark	1950	DF	3.0	29.0	11.2	Montana	*U42*
	1951	DF	3.01	185.0	82.5		*U46*
Instar II budworm per ft^2 bole bark	1956	DF	.8	222.8	34.6	Montana	*U218*
		DF	.1	10.8	3.8		
		DF	.9	118.3	43.3		
		DF	2.1	233.9	38.3		
		DF	2.3	129.5	55.8		
		DF	0	49.2	19.2		
		DF			62.9		
		DF	4.2	23.9	12.4		
		DF	3.9	14.1	9.6		
		DF	.4	8.3	4.8		
		DF	.4	50.2	18.6		
	1959	DF	0	101.4	19.1		*U238*
Instar V budworm per 1,000 in^2 foliage	1965	DF	36.5	46.5	40.7	Montana	*118*
		ES	19.4	50.9	30.0		
		SF	35.5	59.4	45.3		
Pupae per 15-inch foliage twig	1965	DF	0	.8	.2	S. Idaho	*U143*
		DF	.2	1.9	0.7		
		DF	0	3.0	2.0		
		DF	.2	1.9	.5		
Emerged moths per 15-inch foliage twig	1959	DF	0	3.5	1.1	Montana	*U238*
	1960	DF			1.0		*U223*

[1]Symbols: DF, Douglas-fir; WF, white fir; ES, Engelmann spruce; SF, subalpine fir.

Table 15.--*Statistical significance of correlations between some measured and subsequent metamorphic populations of the western spruce budworm and intervening defoliation levels in 25 Douglas-fir stands in Montana (from Terrell and Fellin (U238))*

Population	1958-1959 hibernating larvae	1959 defoliation	1959 emerged moths	1959 egg masses
1958 egg masses per 1,000 in^2 foliage	Not significant r = +0.395 at p=0.05, r=0.423	Highly significant r = +0.673 at p=0.01, r=0.505	Not significant r = 0+.367 at p=0.05, r=0.413	Significant r = +0.434 at p=0.05, r=0.396
1958-1959 hibernating larvae per ft^2 bole bark		Highly significant r = +0.542 at p=0.01, r=0.537	Not significant r = +0.228 at p=0.05, r=0.423	Not significant r = +0.158 at p=0.05, r=0.423
1959 defoliation percentage			Highly significant r = +0.650 at p=0.01, r=0.526	Highly significant r = +0.667 at p=0.01, r=0.505
1959 emerged moths per 15-in foliage twig				Highly significant r = +0.862 at p=0.01, r=0.526

Table 16.--*Measurements of four successive metamorphic stages of the western spruce budworm and of the intervening percentage of defoliation in 25 Douglas-fir stands in Montana, 1958-1959 (from Terrell and Fellin (U238))*

	Plot	1 Egg masses per 1,000 in^2 1958	2 Overwintering larvae per ft^2 1959	3 Percentage of defoliation 1959	4 Moths per 15 in. twig 1959	5 Egg masses per 1,000 in^2 1959
1	Bitterroot	0.58	1.5	8.6	0.00	0.00
2	Rock Creek	9.80	--	44.3	--	10.80
3	Blackfoot	11.44	14.5	42.3	3.20	16.56
4	West Continental	13.40	36.9	43.7	0.40	11.66
5	South Continental	16.12	13.0	62.2	1.40	7.78
6	Pioneer	0.94	1.6	35.2	0.10	0.32
7	Lima	0.50	0.1	13.5	0.05	0.24
8	Ruby	0.98	10.2	11.3	0.25	3.26
9	Madison	17.66	5.9	34.7	0.60	18.46
10	Hebgen	0.00	0.5	0.3	0.00	0.18
11	Centennial	4.74	28.1	54.5	0.90	12.64
12	Tobacco Root	1.34	0.0	1.8	0.00	0.00
13	Lincoln	12.66	101.4	72.7	2.65	21.98
14	Marysville	4.86	12.3	53.3	2.70	35.18
15	Elkhorn	6.30	8.6	50.1	1.15	10.62
16	Big Belt Mts.	2.04	0.1	4.0	0.50	1.10
17	Deep Creek	20.48	2.2	36.8	1.85	15.66
18	Smith River	14.64	--	84.4	2.70	21.32
19	White Sulphur	6.88	3.7	90.0	3.50	36.58
20	Bridger	12.92	3.0	67.5	0.65	10.36
21	Crazy Mts.	10.32	35.3	12.9	0.65	3.92
22	Hyalite	3.84	---	30.2	---	3.56
23	Pine Creek	19.16	84.5	92.8	0.55	7.28
24	Mill Creek	7.40	1.8	11.8	0.15	2.32
25	Slough Cr. (YNP)	5.14	55.5	55.0	1.15	4.08
	Total	204.14	420.7	1,013.9	25.10	255.86
	Average	8.16	19.1	40.6	1.09	10.24

Table 17.--*Residual effects on major forest resources of forestwide host tree damage caused by outbreaks of the western spruce budworm*

Forest use	Tree age class	Nature of tree damage	Residual effect of damage	Impact[1]	Importance[1]
Commercial	Old-growth	Light to heavy defoliation	Reduced radial and longitudinal growth.	-	S/RC
			Increased host tree susceptibility to subsequent lethal bark beetle attack, with consequent diminished timber yield.	-	G/RC
		Top killing	Diminished timber yield.	-	G/NR
			Increase in subsequent fungal wood rot, with consequent diminished wood quality and timber yield.	-	M-G/NR
			Increased host tree susceptibility to subsequent attacks of bark and engraver beetles or wood-boring insects, with consequent diminished timber yield.	-	G/NR
		Mortality	Reduced timber yield.	-	S-G/NR
			Created openings in the forest canopy for possible establishment of seedlings of		
			desirable tree species.	+	S-M/RC
			undesirable tree species.	-	S-M/NR
			herbs and shrubs that inhibit tree regeneration.	-	S-M/RC
			herbs and shrubs that aid tree regeneration.	+	S-M/RC
		Budworm-infested cones	Loss of seed source in good cone-production years.	-	S-G/RC
		Physiologic cone abortion	Loss of seed source for one or more years.	-	S-G/RC
	Immature	Light to heavy defoliation	Reduced salability of Christmas trees.	-	G/RC
			Reduced radial and longitudinal growth, with consequent diminished timber yield of crop trees at end of fixed rotation.	-	S/RC
			Induced adventitious budding, with consequent foliage and crown form qualities undesirable for Christmas trees.	-	S-G/NR
			Natural thinning resulting from possible accelerated decline of intermediate or suppressed trees.	+	S-G/NR
	Immature	Death of terminal leader from defoliation or stem mining	Height growth delayed.	-	S-M/RC
			Induced multiple terminals, with consequent		
			deformed Christmas tree crowns	-	G/RC
			stem crook, a timber defect.	-	S-G/NR
		Top killing, irrecoverable	Height growth terminated.	-	G/NR
			If in crop trees, reduced growing stock.	-	S-M/RC
			Increased susceptibility of remaining stem to fungal wood rot, with consequent diminished wood quality or yield.	-	S-G/NR
			Increased susceptibility of host tree to subsequent lethal attacks of bark or engraver beetles, with consequent diminished timber yield.	-	S-G/NC
		Top killing, recoverable	Height growth delayed.	-	S-M/RC
			New terminals produced, with consequent stem crook, a timber defect.	-	S-G/NR
		Mortality	Established optimum-density growing stock destroyed, with consequent		
			lowered yield.	-	S-G/NR
			expenditure in time and funds to replace.	-	S-G/RC
			Created openings in the forest canopy for possible establishment of seedlings of		
			desirable tree species.	+	S-M/RC
			undesirable tree species.	-	S-M/RC
			herbs and shrubs that inhibit tree regeneration.	-	S-M/RC
			herbs and shrubs that aid tree regeneration.	+	S-M/RC
			Possible natural thinning of overstocked stands by tree groups or individual trees.	+	S-G/RC
			Increased fire hazard from accumulated dead trees or living trees with budworm-killed twigs, branches, or tops.	-	S-G/RC

(con. next page; for footnotes see end of table)

Table 17. (con.)

Forest use	Tree age class	Nature of tree damage	Residual effect of damage	Impact	Importance
Watershed	All	Light to heavy defoliation	Interception of rainfall and subsequent loss by evaporation may be reduced, with consequent increase in water yield.	+	S-M/RC
			Increased spring runoff from snowmelt, with possibilities of accompanying increased erosion, sedimentation, or streambed scouring.	-	S-M/NR
			Reduced transpiration, with consequent increase in water yield.	+	S-M/RC
		Mortality, without replaced ground vegetation	Reduced interception of rainfall and snow, with possible consequent		
			immediate increase in water yield from rainfall.	+	S-M/RC
			increased water yield from spring snowmelt.	+	S-M/RC
			increased erosion, sedimentation, streambank damage, flooding.	-	S-G/NR
Forage	All	Mortality	On suitable sites, forbs, grasses, or shrubs may become established, with consequent increased forage		
			available to grazing livestock and game animals.	+	S-M/RC
			not available to these animals because of standing or fallen dead trees	-	S-M/NR
			Reduced animal access to established forage in sparsely stocked forests because of litter from standing or fallen dead trees.	-	S-G/RC
Wildlife habitat	Pole-size or old-growth	Heavy defoliation	Reduced concealment for crown-inhabiting birds and small mammals.	-	S-G/RC
			Reduced cone production, with consequent loss of food seed for squirrels and some birds.	-	S-G/RC
	Old-growth	Mortality	Increased roosting sites for raptors, increased habitats for woodpeckers, flickers, and sparrow hawks afforded by standing dead trees.	+	S-M/RC
			Inhibited movement of larger animals from litter of standing or fallen dead trees.	-	S-G/RC
	All	Mortality	Created openings in hitherto closed-canopy forests and possible establishment of forbs, grasses, and shrubs, with consequent		
			population increases of rodents, small mammals, and their prey birds or animals.	+	S-G/RC
			seasonal population increases in domestic livestock	-	S-M/RC
			seasonal population increases in larger browsing or fruit-eating mammals.	+	S-G/RC
			removal of protective cover for larger mammals.	-	S-G/RC
Recreation	All	Heavy defoliation	Lessened privacy and protection from elements for picnickers and campers.	-	S-M/RC
			Reduced esthetic values of areas dependent on trees for landscaping.	-	S-M/RC
	Immature	Mortality	In picnic sites, campgrounds, summer or winter homes and resorts		
			reduced landscape esthetics.	-	S-G/RC
			increased fire hazard from accumulated dead trees or living trees with dead twigs, branches or tops.	-	S-G/RC
			increased danger to life and property from falling dead trees.	-	S-G/NR
			increased availability of fuelwood.	+	S-G/NR
	Old-growth	Top killing	Created hazard to recreationists from falling, rotted tree tops.	-	S-G/NR
		Mortality	Created hazard to recreationists from falling dead trees.	-	S-G/NR
			Increased maintenance of roads and trails from fallen dead trees.	-	S-G/NR
			Increased opportunities for ornithologists and recreationists to view birds using dead trees for roosting and nesting.	+	S-M/NR
			Increased opportunities for photographers using photogenic dead trees for landscape composition.	+	S-G/NR
			Expenditures for regeneration or large-tree replacement to maintain tree-oriented landscapes.	-	S-G/RC
	All	Currently infested trees	Nuisance of suspended larvae or dropping frass from overhead host trees in picnic sites and campgrounds.	-	S-G/RC

[1]Symbols: "Impact" column: - means detrimental effect; + means beneficial effect.
"Importance" column: S, slight; M, moderate; G, great; RC, temporary or recoverable; NR, permanent or nonrecoverable.

Table 18.--*Primary parasites of the western spruce budworm recovered in Douglas-fir forests in Montana between 1956 and 1959 (from Dodge (U56))*

Group	Species	Stage of host affected: Attack	Stage of host affected: Emergence	Control effect[1]
I	*Trichogramma minutum* Riley (Hymenoptera: Chalcididae)	Egg	Egg	Poor
II	*Glypta fumiferanae* (Viercek) (Hymenoptera: Ichneumonidae)	II Larvae	IV or V Larvae	Very good
	Apanteles fumiferanae Viercek (Hymenoptera: Braconidae)	II Larvae	IV or V Larvae	Very good
III	Several genera of flies (Diptera: Sarcophagidae)	V or VI Larvae	Pupae	Fair
	Agria affinis (Fallen) (Diptera: Sarcophagidae)	V or VI Larvae	Pupae	Fair
	Phytodietus fumiferanae Rohwer (Hymenoptera: Ichneumonidae)	V or VI Larvae	Pupae	Poor
IV	*Phaeogenes hariolus* (Cresson) (Hymenoptera: Ichneumonidae)	VI Larvae or Pupae	Pupae	Fair
	Ictoplectis quadricingulatus Provancher (Hymenoptera: Ichneumonidae)	VI Larvae or Pupae	Pupae	Poor

[1]Estimated; based upon abundance of the parasites and the percentage of parasitism accomplished.

Table 19.--*Forest lands aerially sprayed with chemical insecticides to control western spruce budworm populations in Idaho, Montana, and Wyoming, 1952 through 1971*[1]

Year	National Forest or Park[2]	Type of treatment	Insecticide used: Toxicant	Insecticide used: Toxicant/acre	Acreage treated
			IDAHO		
1953	Nezperce N.F.	Operational	DDT	1.0 lb.	16,070
1955	Nezperce N.F.	Operational	DDT	1.0 lb.	70,710
	Boise N.F.	Operational	DDT	1.0 lb.	621,210
	Payette N.F.	Operational	DDT	1.0 lb.	216,000
					907,920
1956	Boise N.F.	Operational	DDT	1.0 lb.	211,090
	Challis N.F.	Operational	DDT	1.0 lb.	10,880
	Clearwater N.F.	Operational	DDT	1.0 lb.	119,370
	Payette N.F.	Operational	DDT	1.0 lb.	98,110
	Salmon N.F.	Operational	DDT	1.0 lb.	139,800
	Targhee N.F.	Operational	DDT	1.0 lb.	16,010
					595,260
1957	Boise N.F.	Operational	DDT	1.0 lb.	92,370
	Challis N.F.	Operational	DDT	1.0 lb.	20,110
	Payette N.F.	Operational	DDT	1.0 lb.	374,180
	Salmon N.F.	Operational	DDT	1.0 lb.	55,610
	Targhee N.F.	Operational	DDT	1.0 lb.	118,360
					660,630
1963	Salmon N.F.	Experimental	DDT	0.5 lb.	16,500
	Targhee N.F.	Experimental	Carbaryl	1.6 lb.	2,500
		Experimental	Carbaryl	0.8 lb.	2,500
		Operational	DDT	0.0 lb.)	
		Operational	DDT	0.5 lb.)	190,000
		Operational	DDT	1.0 lb.)	
					211,500
1964	Salmon N.F.	Operational	DDT	0.5 lb.	39,200
		Operational	DDT	1.0 lb.	485,870
		Experimental	Dimethoate	4.0 oz.	1,080
		Experimental	Mexacarbate	1.6 oz.	60
		Experimental	Pyrethrins	0.01 lb.	60
		Experimental	Dichlorovos	0.1 lb.	20
					526,290
1965	Salmon N.F.	Experimental	Malathion	13.0 fl. oz.	4,200
				9.0 fl. oz.	3,950
					8,150
1966	Salmon N.F.	Experimental	Mexacarbate	2.4 oz.	4,860
1967	Sawtooth N.F.	Experimental	Mexacarbate	2.4 oz.	2,300
1969	Nezperce N.F.	Experimental	Mexacarbate	2.4 oz.	6,000
1971	Nezperce N.F.	Experimental	Mexacarbate	2.4 oz.	9,000

(con. next page; for footnotes see end of table)

Table 19. (con.)

Year	National Forest or Park	Type of treatment	Insecticide used: Toxicant	Insecticide used: Toxicant/acre	Acreage treated
			MONTANA		
1952	Bitterroot N.F.	Experimental	DDT	1.0 lb.	12,000
1953	Helena N.F.	Operational	DDT	1.0 lb.	117,140
1955	Bitterroot N.F.	Operational	DDT	1.0 lb.	169,090
	Gallatin N.F.	Operational	DDT	1.0 lb.	77,440
					246,530
1956	Beaverhead N.F.	Operational	DDT	1.0 lb.	251,540
	Helena N.F.	Operational	DDT	1.0 lb.	153,630
	Deerlodge N.F.	Operational	DDT	1.0 lb.	106,800
	Lewis & Clark N.F.	Operational	DDT	1.0 lb.	253,910
					765,880
1957	Beaverhead N.F.	Operational	DDT	1.0 lb.	240,770
	Deerlodge N.F.	Operational	DDT	1.0 lb.	245,330
	Gallatin N.F.	Operational	DDT	1.0 lb.	113,790
	Lewis & Clark N.F.	Operational	DDT	1.0 lb.	113,110
	Yellowstone N.P.	Operational	DDT	1.0 lb.	2,380
					715,380
1958	Helena N.F.	Experimental[3]	DDT	1.0 lb.	6,000
			DDT + Genite	1.0 lb. + 1.0 lb.	6,100
			DDT + Genite	1.0 lb. + 0.5 lb.	6,100
					18,200
1959	Bitterroot N.F.	Operational	DDT	1.0 lb.	126,880
1960	Gallatin N.F.	Operational	DDT	1.0 lb.	66,240
				0.5 lb.	51,610
					117,850
1962	Deerlodge N.F.	Operational	DDT	0.5 lb.	96,590
	Helena N.F.	Operational	DDT	0.5 lb.	209,810
	Lewis & Clark N.F.	Operational	DDT	0.5 lb.	145,360
					451,760
1963	Bitterroot N.F.	Operational	DDT	0.5 lb.	110,190
		Experimental	Malathion	1.0 lb.	40
		Experimental	Malathion	0.5 lb.	13,510
	BLM (Beaverhead	Operational	DDT	0.0 lb.)	
	N.F.)	Operational	DDT	0.5 lb.)	18,000
		Operational	DDT	1.0 lb.)	
	Deerlodge N.F.	Operational	DDT	0.5 lb.	82,320
	Helena N.F.	Operational	DDT	0.5 lb.	35,130
	Lewis & Clark N.F.	Operational	DDT	0.5 lb.	105,080
	Lolo N.F.	Operational	DDT	0.5 lb.	64,400
		Experimental	Phosphamidon	1.0 lb.	5,000
					433,670

(con. next page; for footnotes see end of table)

Table 19. (con.)

Year	National Forest or Park	Type of treatment	Insecticide used: Toxicant	Insecticide used: Toxicant/acre	Acreage treated
			MONTANA (con.)		
1964	Helena N.F.	Experimental	Malathion	12.0 fl. oz.	26,290
	Deerlodge and Lolo N.F.'s	Experimental	Malathion	12.0 fl. oz.	131,410
	Lolo N.F.	Experimental	Malathion	9.0 fl. oz.	160
					157,860
1965	Bitterroot N.F.	Experimental	Mexacarbate	2.4 oz.	1,080
		Experimental	Naled	6.4 oz.	1,160
	Gallatin N.F.	Experimental	Malathion	13.0 fl. oz.	640
	Lewis & Clark N.F.	Experimental	Malathion	9.0 fl. oz.	1,300
		Experimental	Malathion	13.0 fl. oz.	1,610
					5,790
1966	Bitterroot N.F.	Experimental	Mexacarbate	2.4 oz.	5,360
	Beaverhead N.F.	Operational	Malathion	13.0 fl. oz.	62,440
	Gallatin N.F.	Operational	Malathion	13.0 fl. oz.	20,590
					88,390
1968	BLM, ACM (Lolo N.F.)	Experimental	Mexacarbate	1.0 oz.	6,080
1972	Lolo N.F.	Experimental	Mexacarbate	2.4 oz.	500
			WYOMING		
1953	Yellowstone N.P.	Operational	DDT	1.0 lb.	2,000
1955	Yellowstone N.P.	Operational	DDT	1.0 lb.	55,410
1957	Yellowstone N.P.	Operational	DDT	1.0 lb.	69,300

[1]The authors gratefully acknowledge the assistance of Mrs. Shirley J. Schroeder, Administrative Assistant, Division of State and Private Forestry, Northern Region, Missoula, Montana, in compiling portions of this tabulation.

[2]Including intermingled or adjacent forest lands of other public agencies or private owners, particularly those of the U.S. Department of Interior, Bureau of Land Management (BLM), and of the Anaconda (Copper Mining) Company (ACM).

[3]The aerially applied chemicals included an insecticide (DDT) to kill current budworm populations, and an acaricide (Genite) to kill subsequent epidemic populations of the spruce spider mite that might develop.

Table 20.--*Some characteristics of selected chemical insecticides used in the Northern and Intermountain Regions from 1952 through 1971 to control the western spruce budworm*

Insecticide	Chemical classification	Degree of toxicity: LD_{50} [1] Dermal	Degree of toxicity: LD_{50} [1] Oral	Degree of toxicity: General rating [2]	Description
DDT	Chlorinated hydrocarbon	2,510	113	4	Residual insecticide (applications on needles of host tree are absorbed by budworm larvae through the cuticle, especially of the tarsi). Persistent, because of insolubility in water, low volatility, chemical stability at normal temperatures and in sunlight. Low phytotoxicity at recommended dosages. Toxic to wide variety of insects, some predaceous mites. Nontoxic to some phytophagous mites. Inexpensive and in good supply during period of use. Easily applied formulations. Accumulates in fatty animal tissues and may be passed in food chains to become physiologically detrimental or lethal to some animals.
Carbaryl (Sevin) [3]	Carbamate	4,000	850	4	Acts either as a stomach insecticide (application to host tree needles and entry through the mid-gut of budworm larvae) or as a contact insecticide (application to the surface of budworm larvae and entry through the cuticle). Cholinesterase inhibitor. Fast speed of kill. Low volatility. Intermediately residual; less than chlorinated hydrocarbons, more than organic phosphates.
Mexacarbate (Zectran) [3]	Carbamate	1,500-2,500	37	2	Stomach, contact, and residual insecticide. Highly toxic to all budworm larval instars. Nonpersistent; toxicity of application ceases in about 7-10 days; chemically unstable in sunlight. High toxicity allows low dosage rates per acre, aerial spray droplets 120 microns m.m.d. or smaller. Preliminary tests indicate low toxicity to warm-blooded animals and nontarget insects.
Dimethoate (Cygon) [3]	Organic phosphate	400	215	3	Highly toxic to insects, mites, and some animals. Acts either as a stomach, contact, or systemic insecticide or as a fumigant (application on host tree needles vaporizes and enters budworm larvae through tracheae). Cholinesterase inhibitor. Toxicity of application nonpersistent; diminishes quickly because of chemical instability.
Dichlorovos (DDVP)	Organic phosphate	107	90	2	Highly toxic to insects and mites, and to other forms of animal life. Cholinesterase inhibitor. Contact and stomach poison, with some fumigant action.
Malathion	Organic phosphate	4,444	1375	4	Stomach insecticide, some fumigating action. Cholinesterase inhibitor. Nonpersistent; since toxic action deterioriates rapidly (48 hours), requires high initial kill of budworm larvae. Highly toxic to aquatic insects, not to fish; low toxicity to birds and mammals. Relatively costly. Protective clothing and pre- and post-spray cholinesterase tests recommended for persons handling insecticide.
Phosphamidon	Organic phosphate	143	24	2	Acts either as a contact insecticide or a systemic insecticide (insecticidal activity translocated within plant tissues to other parts of host plants). Highly toxic to insects, mites, and humans. Single field test caused significant mortality of aquatic insects and grouse, inadequate mortality of budworms, no distress to mammals. Cholinesterase inhibitor; protective clothing needed for persons handling insecticide. Mixed formulations hydrolyze quickly.
Naled (Dibrom) [3]	Organic phosphate	800	250	3	Contact insecticide and acaricide. Nonpersistent; very short residual life. Mixed formulations hydrolyze quickly. Less toxic to sixth-instar budworm larvae than mexacarbate. No harmful effects on birds and mammals when applied as an aerosol.
Pyrethrum	Organic	1,880	1,500	4	Contact insecticide. Toxic to all invertebrates except Protozoa. Toxic to fish only in direct contact. Slightly toxic to reptiles and amphibia; negligibly toxic to birds and mammals at usual field dosages. May induce hay fever symptoms in some humans. Nonphytotoxic. Use limited by specificity of target insects, short supply, high cost, and deterioriation in storage (oxidation reduces insecticidal activity up to 20% in 1 year). Insoluble in water; soluble in organic solvents and oils.

References: Washington State University (*115*), Brown (*12*), Pattee (*U194*), Scott and others (*U204*), Terrell (*U227*), Robert L. Lyon, Entomologist, Pacific Southwest Forest and Range Experiment Station, Berkeley, California; personal communication.

[1] LD_{50}, median lethal dosage causing 50 percent mortality of test animals; expressed as amount of chemical, in milligrams, per weight of test animal, in kilograms.
[2] Low umerical values in the general rating column indicate high toxicity to man and animals; high numerical values indicate low toxicity.
[3] Proprietary name of insecticide. Names not so referenced are common names of insecticides adopted by the Committee on Insecticide Terminology, Entomological Society of America.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1974 — 677-097 / 63 REGION NO. 8

JOHNSON, PHILIP C., and ROBERT E. DENTON
1975. Outbreaks of the western spruce budworm in the American northern Rocky Mountain area from 1922 through 1971. USDA For. Serv. Gen. Tech. Rep. INT-20, 144 p. (Intermountain Forest and Range Experiment Station, Ogden, Utah 84401.)

The western spruce budworm has severely damaged more than 15 million acres of publicly and privately owned coniferous forests in this area. Abundant information from ranger district annual reports is related about the behavior of the budworm, characteristics of outbreaks of its populations, and kinds and severity of damage. This budworm has chiefly attacked the Douglas-fir, grand and subalpine firs, and Engelmann spruce; it has also attacked western larch, ponderosa pine, and western hemlock.

OXFORD: 416.11; 453--145.718.28*
KEYWORDS: defoliation damage, tortricidae (-forest damage), western spruce budworm, outbreaks, host tree species, host tree impacts, biological control, chemical control.

JOHNSON, PHILIP C., and ROBERT E. DENTON
1975. Outbreaks of the western spruce budworm in the American northern Rocky Mountain area from 1922 through 1971. USDA For. Serv. Gen. Tech. Rep. INT-20, 144 p. (Intermountain Forest and Range Experiment Station, Ogden, Utah 84401.)

The western spruce budworm has severely damaged more than 15 million acres of publicly and privately owned coniferous forests in this area. Abundant information from ranger district annual reports is related about the behavior of the budworm, characteristics of outbreaks of its populations, and kinds and severity of damage. This budworm has chiefly attacked the Douglas-fir, grand and subalpine firs, and Engelmann spruce; it has also attacked western larch, ponderosa pine, and western hemlock.

OXFORD: 416.11; 453--145.718.28*
KEYWORDS: defoliation damage, tortricidae (-forest damage), western spruce budworm, outbreaks, host tree species, host tree impacts, biological control, chemical control.

JOHNSON, PHILIP C., and ROBERT E. DENTON.
1975. Outbreaks of the western spruce budworm in the American northern Rocky Mountain area from 1922 through 1971. USDA For. Serv. Gen. Tech. Rep. INT-20, 144 p. (Intermountain Forest and Range Experiment Station, Ogden, Utah 84401.)

The western spruce budworm has severely damaged more than 15 million acres of publicly and privately owned coniferous forests in this area. Abundant information from ranger district annual reports is related about the behavior of the budworm, characteristics of outbreaks of its populations, and kinds and severity of damage. This budworm has chiefly attacked the Douglas-fir, grand and subalpine firs, and Engelmann spruce; it has also attacked western larch, ponderosa pine, and western hemlock.

OXFORD: 416.11; 453--145.718.28*
KEYWORDS: defoliation damage, tortricidae (-forest damage), western spruce budworm, outbreaks, host tree species, host tree impacts, biological control, chemical control.

JOHNSON, PHILIP C., and ROBERT E. DENTON.
1975. Outbreaks of the western spruce budworm in the American northern Rocky Mountain area from 1922 through 1971. USDA For. Serv. Gen. Tech. Rep. INT-20, 144 p. (Intermountain Forest and Range Experiment Station, Ogden, Utah 84401.)

The western spruce budworm has severely damaged more than 15 million acres of publicly and privately owned coniferous forests in this area. Abundant information from ranger district annual reports is related about the behavior of the budworm, characteristics of outbreaks of its populations, and kinds and severity of damage. This budworm has chiefly attacked the Douglas-fir, grand and subalpine firs, and Engelmann spruce; it has also attacked western larch, ponderosa pine, and western hemlock.

OXFORD: 416.11; 453--145.718.28*
KEYWORDS: defoliation damage, tortricidae (-forest damage), western spruce budworm, outbreaks, host tree species, host tree impacts, biological control, chemical control.

Headquarters for the Intermountain Forest and Range Experiment Station are in Ogden, Utah. Field Research Work Units are maintained in:

- Boise, Idaho
- Bozeman, Montana (in cooperation with Montana State University)
- Logan, Utah (in cooperation with Utah State University)
- Missoula, Montana (in cooperation with University of Montana)
- Moscow, Idaho (in cooperation with the University of Idaho)
- Provo, Utah (in cooperation with Brigham Young University)
- Reno, Nevada (in cooperation with the University of Nevada)

AMERICAN REVOLUTION BICENTENNIAL
1776-1976

GROWING FROM '76
U.S. FORESTRY CENTENNIAL

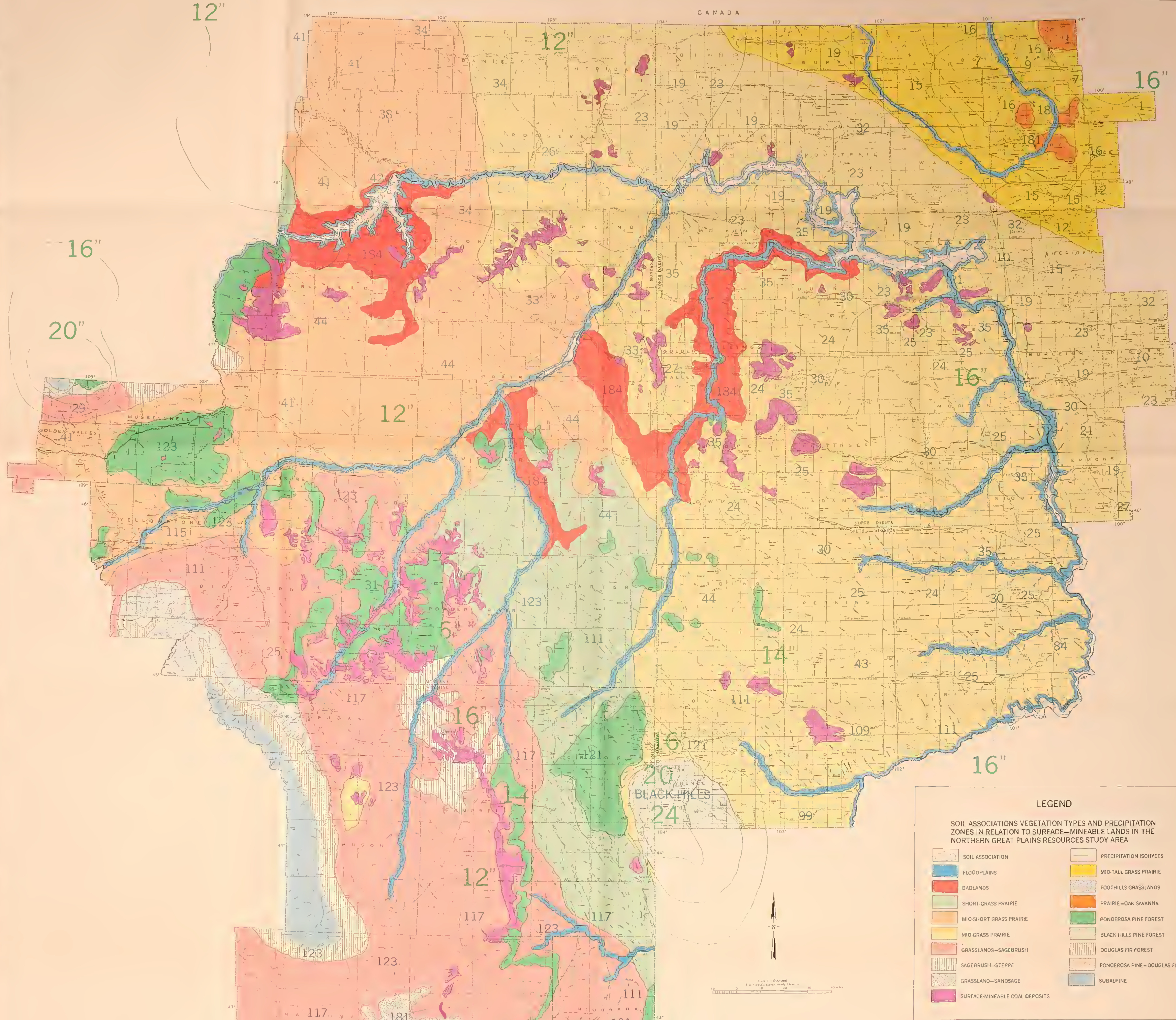
REHABILITATION RESPONSE UNITS

NORTHERN GREAT PLAINS RESOURCES PROGRAM
1974

Prepared By
SURFACE RESOURCES WORK GROUP
(Compiled by Surface Rehabilitation Subgroup)

FIGURE 2

U.S. GOVERNMENT PRINTING OFFICE 1974 - 678-824



MAJOR ECO-SYSTEMS AND SURFACE REHABILITATION FACTORS

NORTHERN GREAT PLAINS RESOURCES PROGRAM

1974

Prepared By

SURFACE RESOURCES WORK GROUP

(Compiled by Eco-Systems Subgroup and Surface Rehabilitation Subgroup)

FIGURE 1

U.S. GOVERNMENT PRINTING OFFICE 1974 — [illegible]